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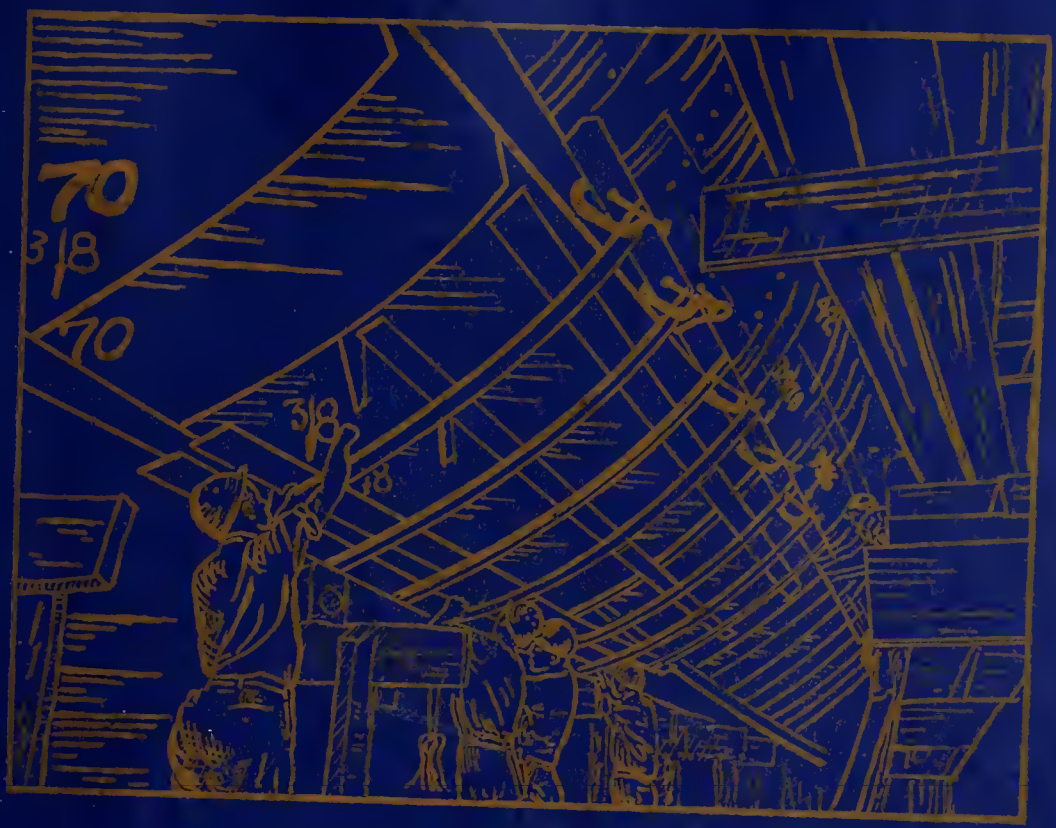

Prepared by the
DIVISION OF INDUSTRIAL EDUCATION
and
SUN SHIPBUILDING AND DRY DOCK COMPANY

BULLETIN 345
Commonwealth of Pennsylvania
DEPARTMENT OF PUBLIC INSTRUCTION
August 1941

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CLASS BOOK

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FOREWORD

This manual has been published to make available instructional materials applicable to the pre-employment and supplementary training of shipfitters. It is largely a revision of a work of similar title which was prepared by the Sun Shipbuilding and Dry Dock Company, of Chester, Pennsylvania. The original material was used in shipfitter training at the Sun yard during the past several years.

Since this revised manual has been compiled especially for use in the training of shipfitters for Sun Shipbuilding and Dry Dock Company, which is engaged in the construction of merchant ships, those making this compilation realize that certain materials may not be applicable to all types of shipyards. However, much of the information presented is standard practice which will be useful in training shipfitters for most plants.

The Sun Shipbuilding and Dry Dock Company; the Pennsylvania Department of Public Instruction; the United States Office of Education; and the School District, City of Chester, jointly assisted in the preparation of this publication. The Sun yard designated personnel to work with Department of Public Instruction representatives and supplied office space in the shipfitting department for those engaged in the preparation of copy.

Acknowledgment is made to the Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania, for the release from copyright of materials which were used as a basis for this revision.

Special acknowledgment is made to Frank M. Hoot, Jr., General Foreman of Shipfitting, and Arthur B. Millay, Foreman of Hull Outfitting, for their work in preparing the original material which was used as a basis for this revision. Mr. Hoot and Mr. Millay also assisted very materially in preparing manuscript for the revised publication, in reading final proof, and in checking drawings.

Sincere appreciation is also expressed to mechanics, leaders, and foremen who cooperated in the preparation and criticism of materials contained in this manual.

Appreciation is extended to Richard W. Hartmann, Coordinator of Trade and Industrial Education, Eastern Region, and to D. Francis Hallowell, Coordinator of Chester Area Defense Training Program, for their assistance in this work.

This bulletin was prepared by Charles F. Zinn, Adviser, Division of Industrial Education, under the general supervision of Paul L. Cressman, Director, Bureau of Instruction, and Urwin Rowntree, Chief, Division of Industrial Education.

FRANCIS B. HAAS
Superintendent of Public Instruction

August, 1941

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PART I

Lining and Tack Welding Steel Hull Members

IMPORTANCE OF LINING AND TACKING

Every shipfitter and lining man should be thoroughly familiar with the operations of lining and tack welding steel hull members in preparation for final welding. Plating, frames, bulkheads, shell or deck sections, etc., must be set in the proper position relative to each other, and their edges must be either straightened, or accurately set to a smooth (fair) curve.

It is important that lining and tacking operations be carefully done. Welded joints or connections must be properly placed to carry the forces directly from one member to another, and clearances must be correct in order to permit satisfactory welds.

Another consideration in performing this work is the final appearance of the ship and its component parts. All edges should be set and tacked in the proper position so that there are no irregularities in the fairness of the structure at the weld. Also, the deflection of adjacent members, owing to weld contraction, must be anticipated and minimized by proper lining and tack welding.

In discussing lining and tacking operations, it is assumed that a competent tack welder is available; therefore, no instructions pertaining to the actual application of welds are included.

Lining and Tacking a Butt in Deck Plating

LINING SHELL BUTTS AND SEAMS

The object in lining plate butts is to bring the two plates into such a position that a smooth, continuous surface will be maintained. This is accomplished by means of "dogs" and other auxiliary gear.

Figure 1 shows the type of dog needed to bring into position the welded butts and seams in shell, deck, or bulkhead plating.

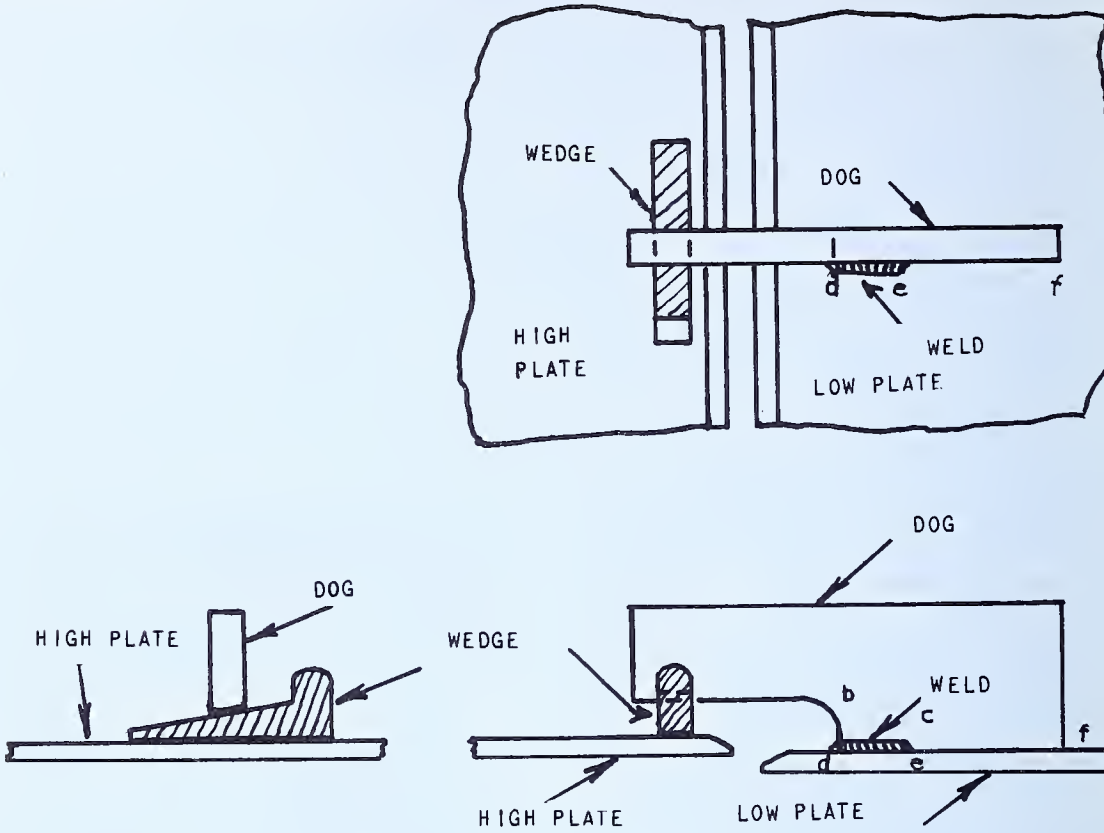


Fig. 1 -- Use of Dog in Lining a Plate Butt

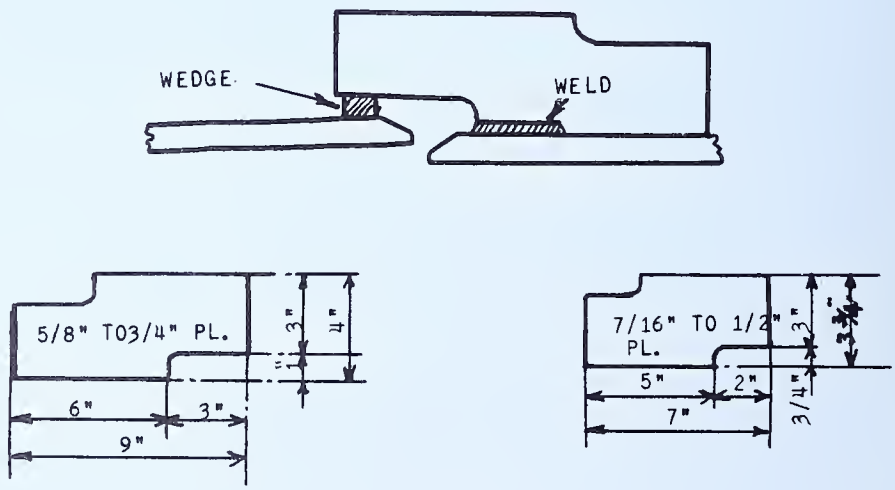


Fig. 2 -- Special Dog for Repeated Use

Each dog is welded in place as shown, and a wedge is driven against the high plate until the edges are flush. When a butt length of a few feet has been "flushed", it is tack welded, after which the dogs are removed and rewelded further along the plate edge.

Detail of Dog for Butt

MAKING A DOG

A dog is burned out of a piece of scrap plate from 3/8" to 1" thick, depending upon the force needed to pull the plates into position. Usually heavy plating requires heavy dogs. In making a dog the corner "b", Fig. 1 should be rounded so that it will not tear when subjected to a strain.

Another way of making a dog for the same purpose is shown in Fig. 2. This dog can be used twice as many times as that shown in Fig. 1. When the bottom of this dog wears out or becomes too rough to be efficient (owing to repeated welding), the dog can be turned upside down and used several more times.

APPLYING A DOG

It is very important that the weld be concentrated as close to the wedge as possible. When this is done, all of the weld is useful. Any weld between points "e" and "f", Fig. 1, would be wasted because the force on the dog in that section is downward. The weld between points "d" and "e" is very valuable in that the force on the dog is upward and is a maximum at point "d". For this reason the most important part of the whole weld is that across the thickness of the dog at point "d".

It is also important to put the weld "c" (between "d" and "e") on the side of the dog from which the wedge is to be driven. The side selected will depend on the amount of room available for swinging the maul or hammer. No more weld should be applied to the dog than is required.

USE OF FLAT BAR AND YOKE

In Figure 3 is illustrated a method of lining plate butts in special cases where a strong force is needed. The yoke enables the welding to be concentrated close to the edge of the lower plate, where it will do the most good. Otherwise this method is similar in effect to the use of the dog.

Caution: When the plates are of different thicknesses, always consult drawings or leader to find out whether plates are flush at top or bottom surface.

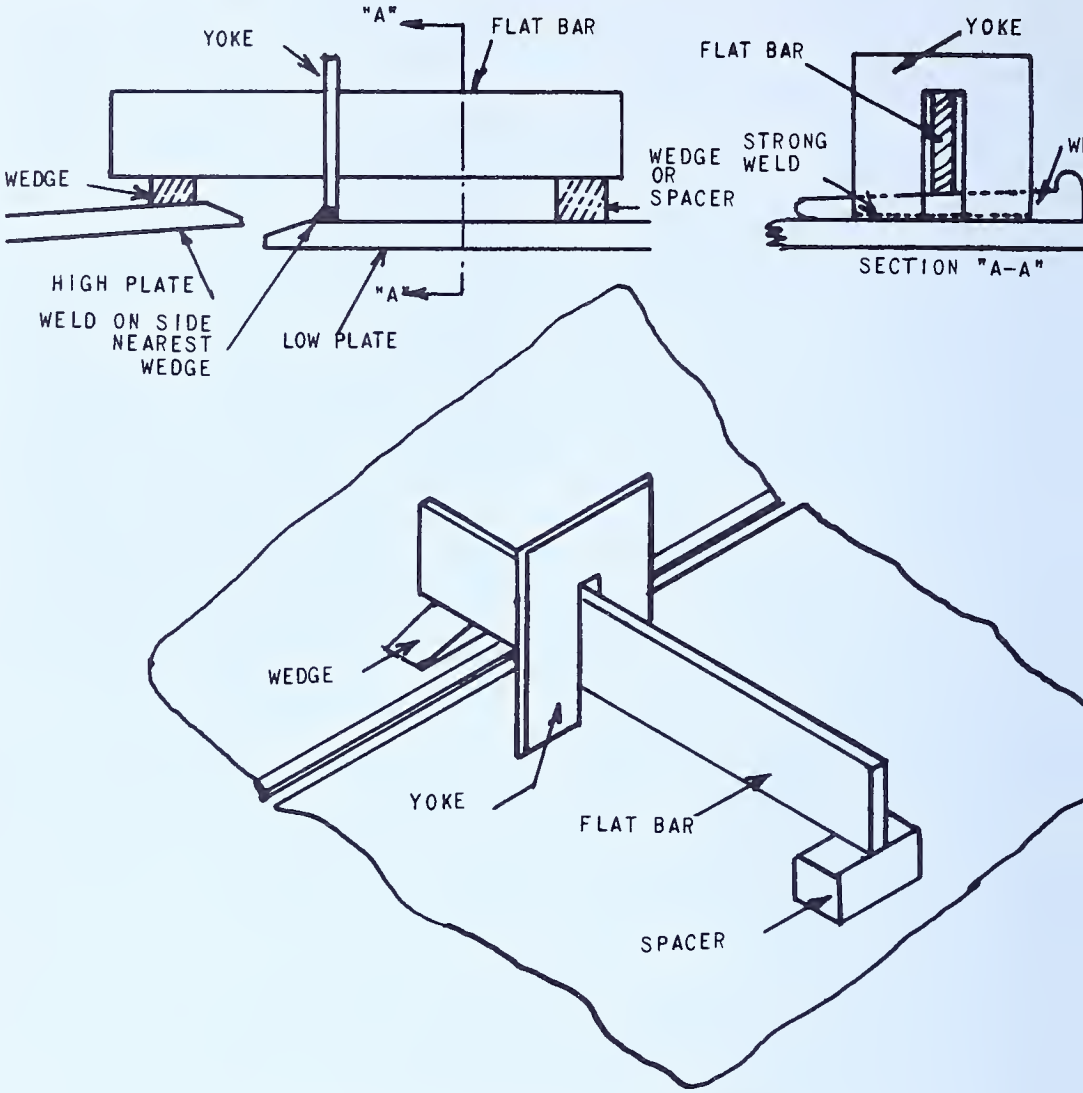


Fig. 3 -- Flushing Butts with Yoke and Flat Bar

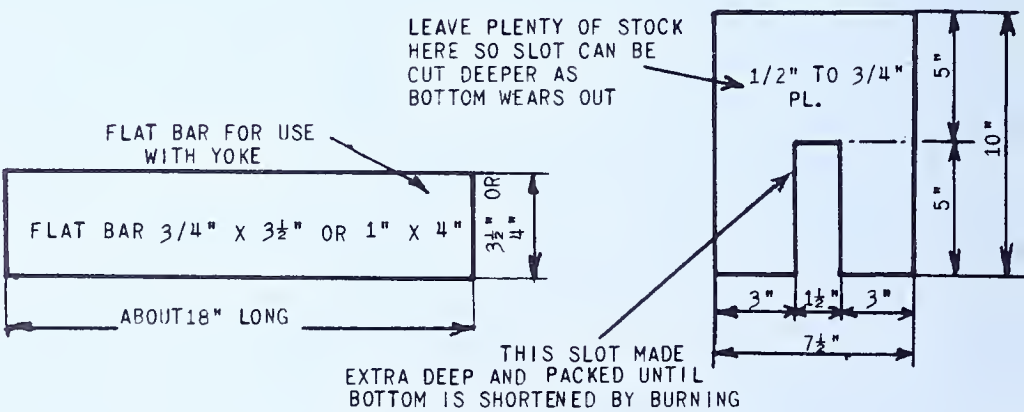
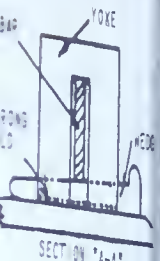

LEAVE PLENTY OF STOCK HERE SO SLOT CAN BE CUT DEEPER AS BOTTOM WEARS OUT
1/2" TO 3/4" PL.
5"
10"
5"
FLAT BAR FOR USE WITH YOKE
FLAT BAR 3/4" X 3½" OR 1" X 4"
3½" OR 4"
ABOUT 18" LONG
3"
1½"
3"
7½"
THIS SLOT MADE EXTRA DEEP AND PACKED UNTIL BOTTOM IS SHORTENED BY BURNING

Fig. 4 -- Detail of Yoke and Flat Bar.



Questions

1. In lining a butt between two plates of unequal thickness, the top or the bottom surfaces of the two plates be made
2. How much weld should be applied to a dog for use in flus butt?
3. In what way does the flat-bar and yoke method increas force which can be applied?
4. Why is a narrow slot used in the yoke in Fig. 3?
5. Why should stock be left on a yoke when it is first made?
6. Give two reasons why the weld in Fig. 1 is applied as
7. Why is it important that lining and tacking operations be fully performed?
8. What is a dog?

LINING BULKHEADS AT DECKS

When a bulkhead, web frame, or other member is to be welded to a deck, care must be taken to line the plate edg perly on its "set" marks. (Set marks are groups of center marks showing exactly where the edge of the plate should b They are applied to the deck by the layout man in the shop the shipfitter on the ship).

SETTING BULKHEAD TO MARKS

The general practice is to straighten (align) the whole bu or section before starting to pull it tight to the deck. A line, as "c" in Figure 5, is snapped on the deck alongside t marks, and parallel to them, about four inches away. The bu can then be straightened along its full length by wedging i until it is exactly four inches from this chalk line.

To accomplish this, a small rectangular lug (burned scrap plate) is welded to the deck as at "a" in Figure 5. A is then driven between the bulkhead and the lug, forcing the over to its proper position. Such lugs and wedges are a wherever needed.

PULLING DECK TO BULKHEAD

In Fig. 5 at "b" and "d" is shown the use of a bolt an for pulling the deck to the bulkhead plating. When the tightened with a hand wrench, or an impact wrench (knock machine), the bolt pulls the deck hard against the bulkhead, for tack welding. A long bolt (10" or 12") should be use height of the clip on the bulkhead depending on the length bolt. (With repeated use, the bolt shortens, owing to the end being burned off each time).

APPLICATION OF CLIPS

Clips should always be welded to the bulkhead as shown in Fig. 6. The flange of the clip between "a" and "b", which has a hole for the bolt, is horizontal. The weld is made only along the top. The other flange of the clip, from "b" to "c", is downward. No weld is needed on this vertical flange because the force of the bolt pushes it tight against the bulkhead. Care should be taken when installing clips and bolts, so that when the bolt is tightened, the washers will bear flat on the clip. This will cause a uniform pull on the top weld and also prevent bending of the bolt.

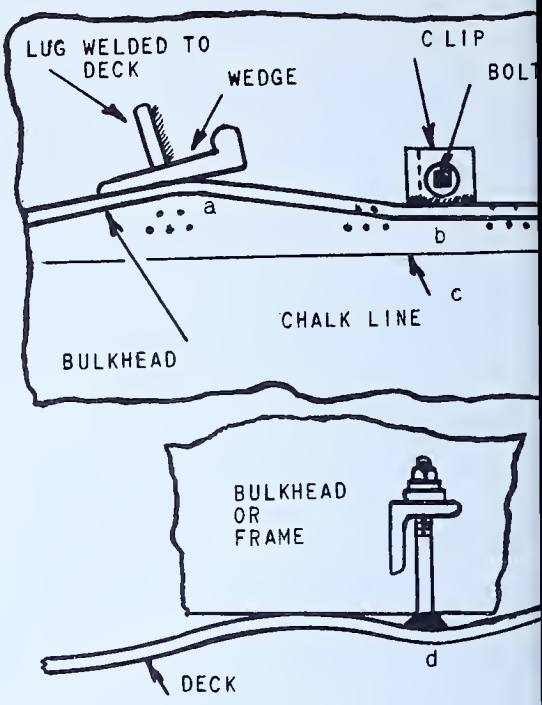


Fig. 5 -- Lining Bulkhead at De

AMOUNT OF WELD REQUIRED

When a bolt and clip are used together, the amount of welding along the top of the clip should not be greater than the weld which fastens the bolt to the deck. Tables I, II, and III show the proper amount of weld to be used.

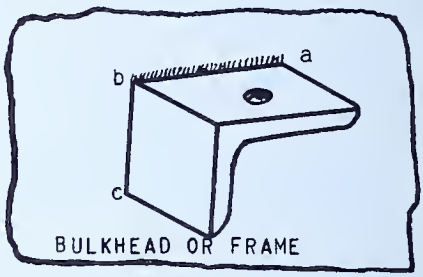


Fig. 6 -- Attachment of Clip

Example: Suppose a deck is to be pulled up to the bottom of a bulkhead with a clip and a 3/4" bolt. Assume first that the head is on the bolt, Fig. 7. From Table III, it is seen that a 3/4" bolt requires a 3/16" weld all around the head in order that the weld be as strong as the bolt itself.

In other words, the distance "abcd" around the bolt head is 4½". A 3/16" fillet weld which is 4½" long will be as strong as the steel in the bolt.

The weld "ef" on the clip must also be as strong as the bolt. From Table II it is found that for a 1/4" weld, the length needed is 2-7/8". In the sketch (Fig. 7) is a weld 2-7/8" long. If a 5/16" weld were used, the length would be 2-1/4".

Now suppose that the head has been burned off the bolt and the shank is to be welded to the deck. In Table I, for a 3/4" bolt, it is found that a 5/16" weld is needed. That is, the circumference, or distance around the shank "abc" in Fig. 8 is 2-3/8". A 5/16" weld around this shank is as strong as the steel in the bolt. The weld on the clip is the same in either case.

Table I -- Size of Weld to Equal Bolt Strength--Bolts without Heads

Dia. of bolt	Circum-ference of shaft	Size of weld needed
5/8"	2"	1/4"
3/4"	2-3/8"	5/16"
7/8"	2-3/4"	3/8"
1"	3-1/8"	1/2"

Table II -- Weld Needed on Top of Clips to Equal Strength of Bolts

Dia. of bolt	3/16" weld	1/4" weld	5/16" weld	3/8" weld	1/2" weld
5/8"	2-5/8"	2"			
3/4"		2-7/8"	2-1/4"		
7/8"			3-1/8"	2-5/8"	
1"				3-3/8"	2-1/2

Table III -- Size of Weld to Equal Bolt Strength--Bolts With Heads

Dia. of bolt	Distance around head	Size of weld needed
5/8"	3-3/4"	3/16"
3/4"	4-1/2"	3/16"
7/8"	5-1/4"	3/16"
1"	6"	1/4"

Pulling Deck to Bulkhead

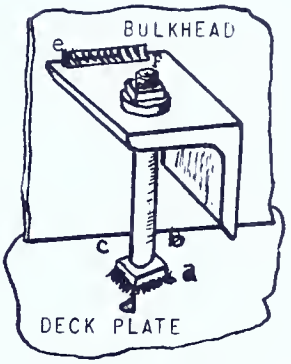


Fig. 7 — Clip and Bolt With Head

Clip Welded on Stiffener

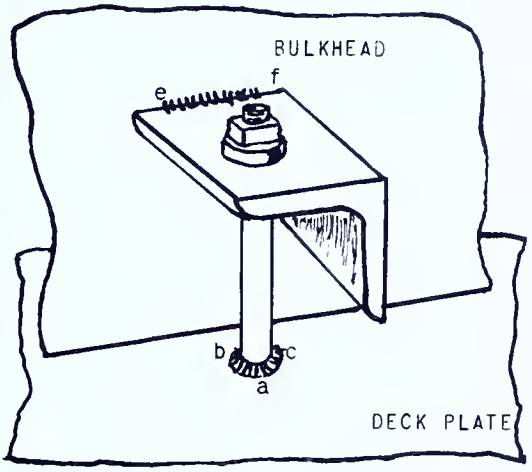
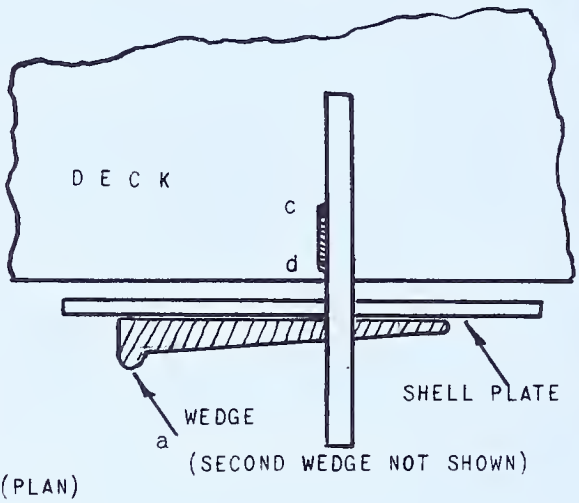


Fig. 8 -- Clip and Headless Bolt

PULLING SHEERSTRAKE TO DECK

When it is necessary to pull a sheerstrake (top shell plate) t a deck for welding, a dog, similar to that shown in Fig. 9, i used. The same type dog can be used whenever a bulkhead project a few inches above the deck. The dog is welded to the deck plate from "c" to "d" as shown in Fig. 9. We need not calculate the total force a wedge can develop, although for usual cases a 1/4" fillet weld about 2-1/2" long will be sufficient. If the plates are very heavy and hard to move, the weld can be made stronger.

Pulling Sheerstrake to Deck



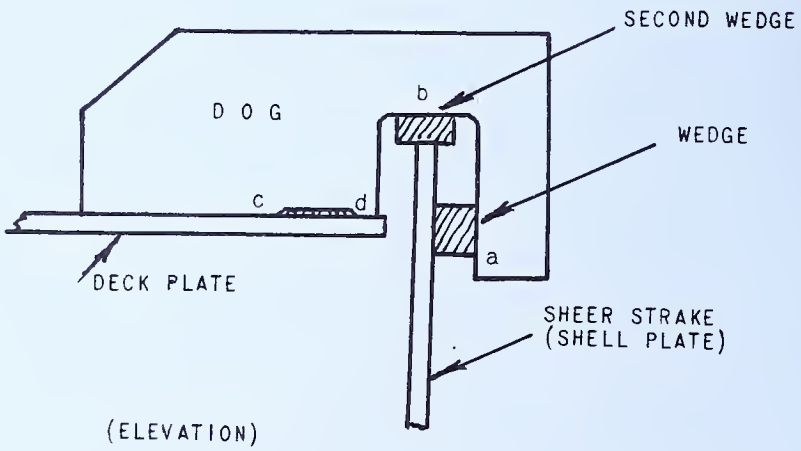


Fig. 9 -- Special Dog for Sheerstrake

The wedge at "a", Fig. 9, which pulls the shell plate in, must be placed level with the deck. If it is too high or too low, it will not be in line with the weld "cd" and will tend to tear the dog loose. The second wedge "b" is used to raise the deck plate, if this is required to put it on its set marks. *Both wedges* should

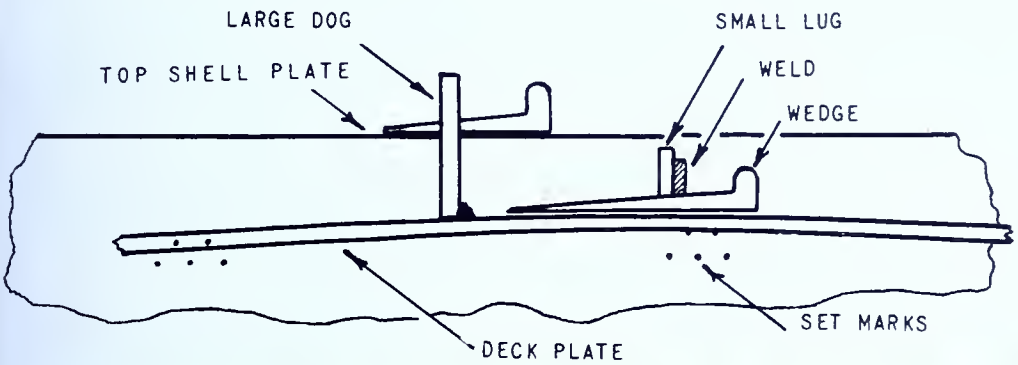
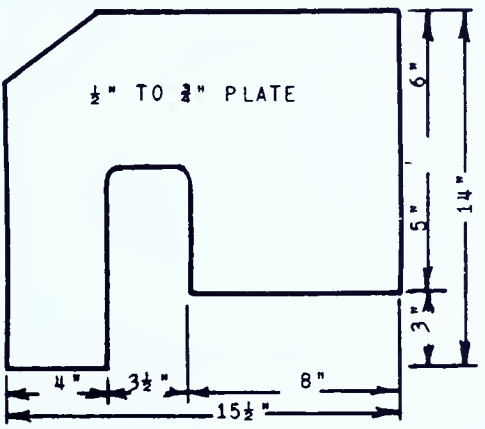


Fig. 10 -- Wedging a Deck Down to its Set Marks

Lining and Tacking Deck at Shell

Fig. 11 -- Sheerstrake Dog Dimensions



be driven from the side of the dog on which the weld is place If it happens that the deck must be pushed downward to meet set marks, a small lug must be welded to the shell plate as sh in Fig. 10. Note: The deck should be lined to its set marks bef the sheerstrake is wedged in. As in all other cases, the we should be on the side of the lug from which the wedge is to driven.

LINING SHELL AND DECK LONGITUDINALS

When a flanged plate or other type of longitudinal (stiffen has to be forced down to a shell plate or up to a deck, a yoke used as shown in Fig. 12.

Wedge "a", when driven under the yoke, will force the lon tudinal down tight against the plate, where it can be tacked. the bottom of the yoke, a wedge "b" can be driven against longitudinal to force it over to its set marks. If the longitudi needs to go in the other direction, packing and a wedge can applied at "c" as shown in Fig. 12. A yoke made of a flat pl as above may be used for light work. For heavier jobs it is satisfactory because the top of the yoke slides along the top the longitudinal when the wedge is driven, bending the yoke and often breaking the weld. To overcome this, the yoke can be made of angles and a flat bar, welded together as shown in Fig. 13. The weld should be along "ab" and "cd" as shown. No weld is needed along the edge "de" because the force of driving the wedge will force this flange down tight against the plate. This

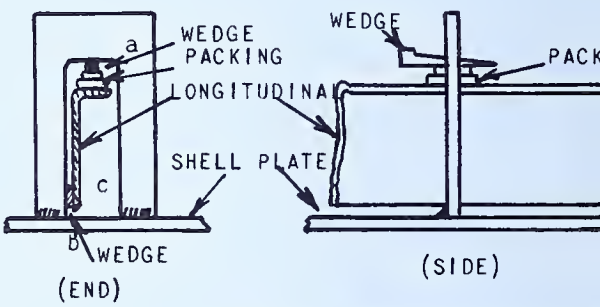


Fig. 12 -- Wedging Down Longitudin With Yoke

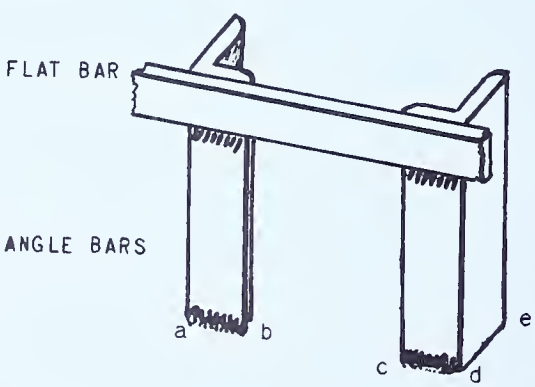


Fig. 13 -- Angle Bars Welded to Form Stiff Yoke

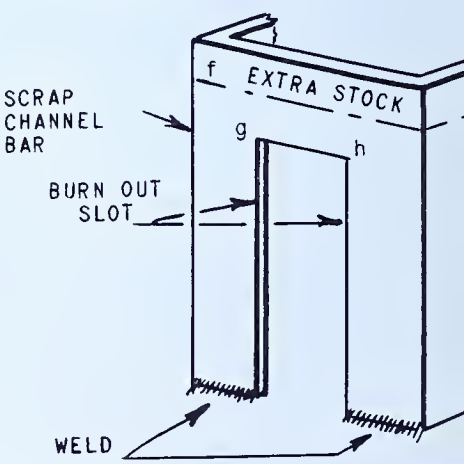


Fig. 14 -- Slotted Channel for Yoke

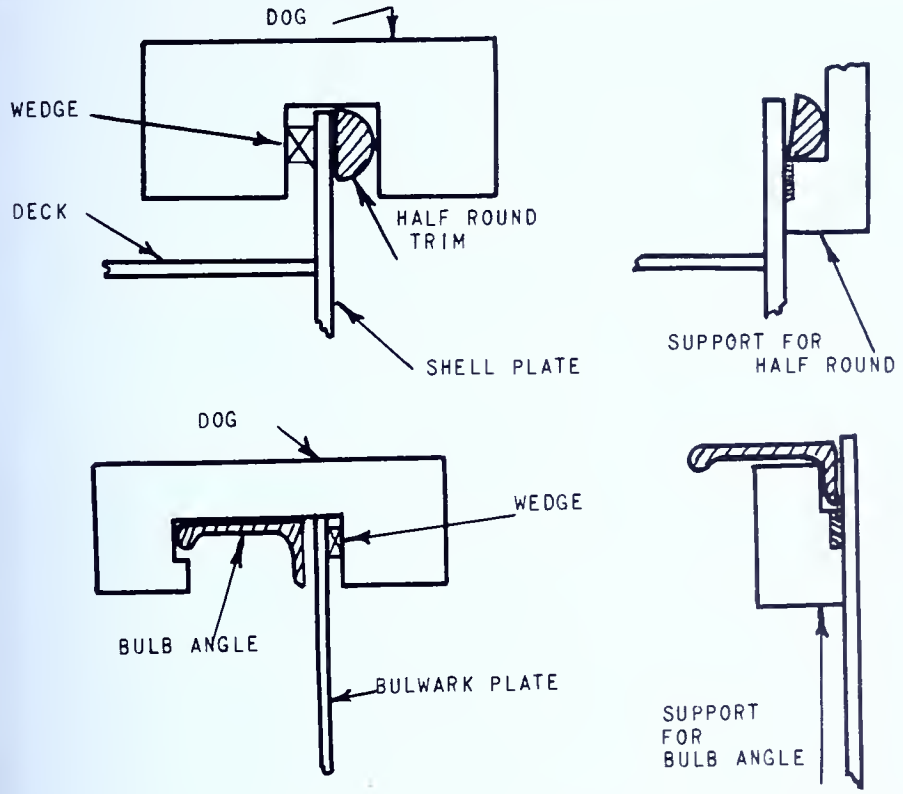


Fig. 15 -- Dogs Used in Lining Bulwark Stiffeners

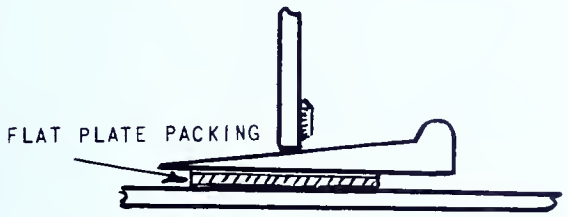


Fig. 16 -- Wedge Correctly Used

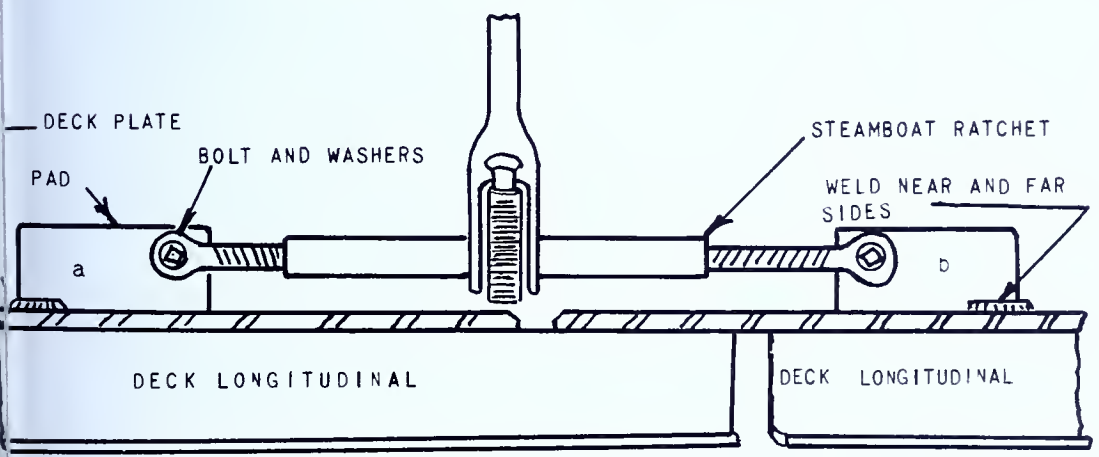


Fig. 17 -- Pulling Deck Sections With Ratchet

flange prevents the yoke from "tripping" over. This method wou be useless, however, if the wedge were driven from the wrong sid it must be driven from the welded side. Sometimes a *scrap* pie of channel bar is slotted as a yoke, (Fig. 14). The two flang of the channel serve the same purpose as the angle bars in t previous type. All these yokes should have the slot burned d deeper than the longitudinal on which they are to be used. Pad ing can be applied under the wedge until the bottom has be burned off a few times. Extra stock should be left on the t (see "f", Fig. 14) so that it will still be strong enough wh the top of the slot "gh" is burned higher.

Questions

1. Why are angles used in building up yokes for heavy work?
2. When possible, why is extra stock left at the top of a yoke?

USE OF STEAMBOAT RATCHET

The following methods are employed when it is necessary use a steamboat ratchet to pull together two adjacent sections deck or shell plating. The pads into which the turnbuckle bolted should, whenever possible, be welded directly opposite longitudinal or stiffener, in order to avoid bending the plate

The first method is illustrated in Fig. 17. This is used wh the two sections may be expected to come together with an avera amount of pull. The pads "a" and "b" have holes for secure bolting the ends of the turnbuckle. When the pad is welded on the position shown, the holes should be high enough above t deck (about 4") for the spur teeth in the center of the ratchet to be clear of the plating.

In Fig. 18 are shown the approximate dimensions of the ordinary pad to be used in this manner. A two inch landing should be used for the holes in the corners. Care should be taken to have the hole in the pad burned out very smoothly, or punched, so that the corner will not be likely to tear out before the full strength of the bolt is utilized.

In Fig. 19, at "a", is a washer between the pad and the turnbuckle, used to take up the clearance which would otherwise occur, owing to the shoulder on the eye of the ratchet. Without this

Pulling Deck Sections--Bolt in Double Shear

washer, the bolt used would bend and fail before its full strength could be used. This bolt must always be pulled up tight. The weld at "b" in Fig. 19, runs around the end of the pad and is evenly applied on both sides. The total length of weld to be used on one pad (for different size bolts) can be obtained from the left hand section of Table IV.

Figure 20 shows how the same type pad can be used to put a bolt in double shear. The bolt, in double shear, is resisting the pull in two places and therefore will hold twice as much strain.

Another method of putting a bolt in double shear is by welding two pads to the deck instead of one (see Fig. 21). The total length of 1/4" weld for these pads or for the single pad in Fig. 20 can be found in Table IV, section for bolts in double shear.

When it is impossible to place the pads over or opposite a longitudinal or stiffener, a flat bar about three feet long may be used at each end of the turnbuckle, as shown in Fig. 21. The bar is bent to an offset and one end welded to the deck at "a". The ratchet is bolted to the other end of the flat bar, a wood or steel block being placed under the bolt to keep the ratchet gear clear of the deck. This arrangement prevents the plate from bending downward as it would with the use of a short pad. The block should be long enough to spread the pressure over a large area of plating. The same result can be obtained by using an angle or T-bar clip about three feet long, as shown in Fig. 23.

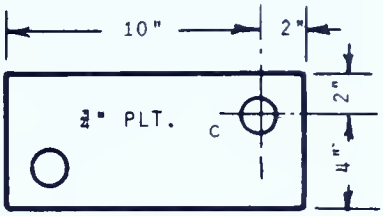


Fig. 18 -- Pad for Use With Ratchet

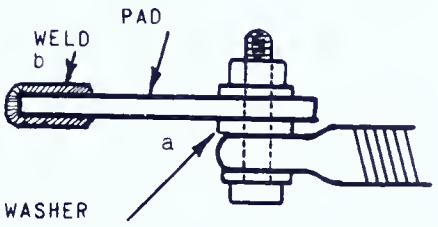


Fig. 19 -- Bolt in Single Shear

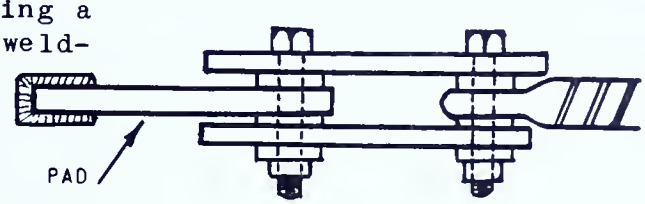


Fig. 20 -- Bolts in Double Shear

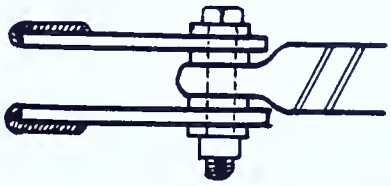


Fig. 21 -- Single Bolt in Double Shear

Steamboat Ratchet--Bolts In Single Shear

Table IV -- Length of 1/4" Weld to Equal Shear Strength of Mild Steel Bolt

Bolt in single shear

Dia. of bolt	Shear value	Length of 1/4" bead
3/4"	5,301	2-3/8"
7/8"	7,216	3-1/8"
1"	9,425	4"

Bolt in double shear

Dia. of bolt	Shear value	Length of 1/4" bead
3/4"	10,602	4-1/2"
7/8"	14,432	6"
1"	18,850	7-3/4"

Table V -- Length of Weld to Equal Shear Strength of Special Steel Bolts

Bolt in single shear

Bolt Dia.	Shear value	Length of 1/4" bead
3/4"	10,602	4-1/2"
7/8"	14,432	6"
1"	18,850	7-3/4"

Bolt in double shear

Bolt Dia.	Shear value	Length of 1/4" bead	Length o 3/8" bea
3/4"	21,204	9"	5-5/8"
7/8"	28,864	12"	7-3/4"
1"	37,700	15-1/2"	10"

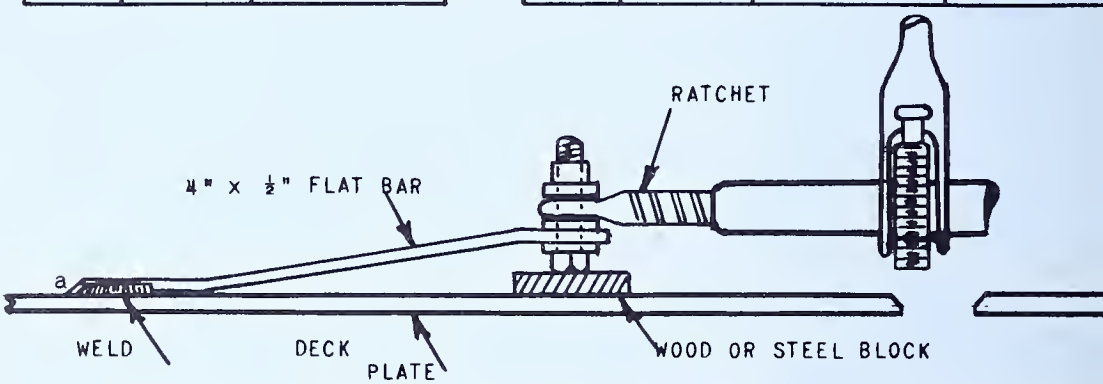


Fig. 22 — Ratchet Connection to Deck When no Longitudinal is Beneath

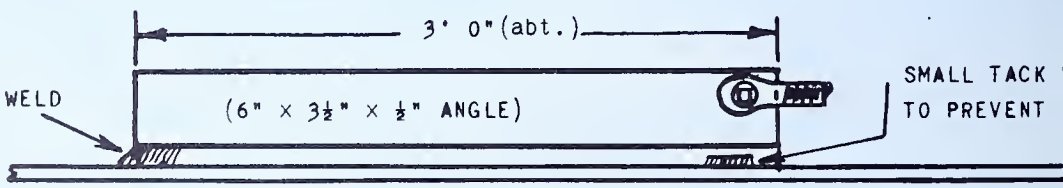


Fig. 23 -- Scrap Angle or T-Bar for Ratchet Connection

Questions

1. Why should ratchet connections be placed opposite stiffeners
2. Explain what is meant by "double shear"?
3. Why is packing used under the bolt head in Fig. 22?

USE OF HYDRAULIC JACK

Hydraulic jacks and hydraulic pumps are used when it is necessary to apply a great pressure, or push, to some member of the ship. For instance, they can be used to push into place the bottom of a transverse wing bulkhead. This operation will be explained later. In Fig. 24, the jack consists of a hollow cylinder "a" into which is fitted a large piston or plunger "b". There is a connection on the side for a flexible hose "f" which brings in water at high pressure. The water pushes the piston upward from the

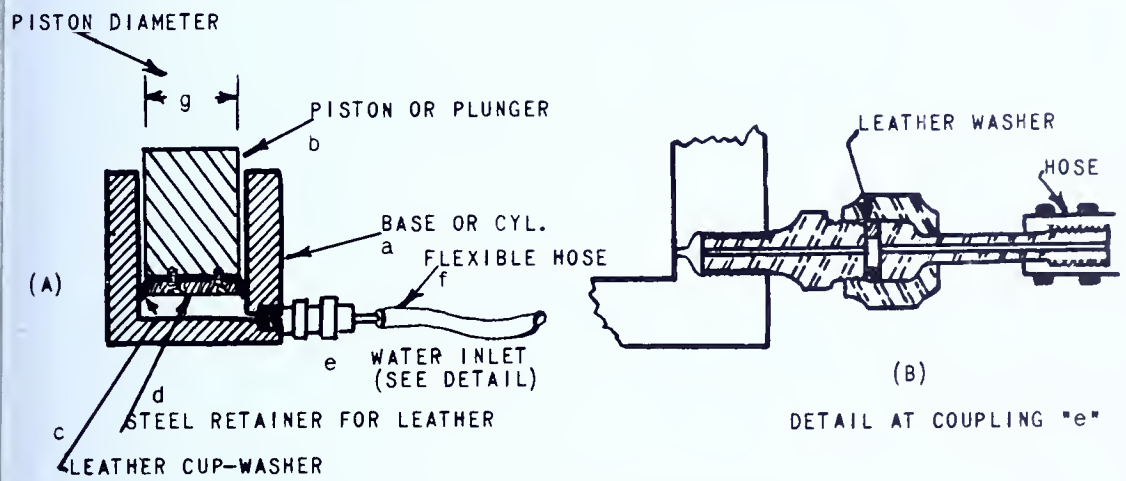


Fig. 24 -- Hydraulic Jack

base. A large force can be applied, depending upon the area of the end of the piston and upon the pressure of the water led into the base.

Water is prevented from leaking past the piston by a leather washer "c", or cup, fastened to the bottom of the piston by a steel plate "d" which is held by machine screws. Each morning before the jack is used, the piston should be pulled or pumped out and the walls and leather thoroughly cleaned and greased. Light oil and tallow are very good for this purpose. The flexible hose "f" connects to the chamber by means of a fitting "e" and a small hole drilled near the bottom of the base. When using this jack, care should be taken that no steel member or packing is allowed to press against the brass fitting at "e", which is easily broken. The coupling at "e" is shown in detail in Fig. 24 (B). The leather washer must be in place and it is essential that there be no leaks anywhere in the pump, hose or jack. The smallest leak would release the pressure.

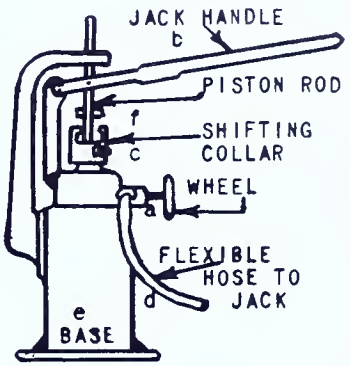


Fig. 25 -- Pump for Hydraulic Jack

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HYDRAULIC PUMPS

In Fig. 25 is sketched a hydraulic pump for use with the jac The base "e" is filled with clean water (with anti-freeze in c weather) by means of a filler plug. The wheel "a" is turned close the needle valve which holds the pressure in the line. T shifting collar "c" must be turned so that it engages the pist rod "f" and causes the larger piston (and the collar itself) move when the handle "b" is moved. This causes the water to pumped at the greatest possible speed. This setting should be c tinued until it is too hard to pump. The shifting collar shou then be rotated to the position at which only the small piston the end of the piston rod "f" is allowed to move. It is sometir necessary to open the needle valve a trifle by means of the wh "a" to reduce pressure enough to get the collar down to its b tom position and secure it. The valve should then be tightened the maximum pressure applied by means of the small piston.

OPERATION OF JACK AND PUMP

If the jack in use will not apply enough force to do the required job, a jack with a larger piston diameter (see Fig. 24 "g") should be used. With a constant water pressure, if the piston diameter is doubled, the force developed will be four times as much, (since the force depends on the piston area). When possible, it is advisable to have the pump at a lower level than the jack itself. Then when the needle valve is opened to release the pressure, the water will tend to run out of the piston down into the cylinder in preparation for using the jack again.

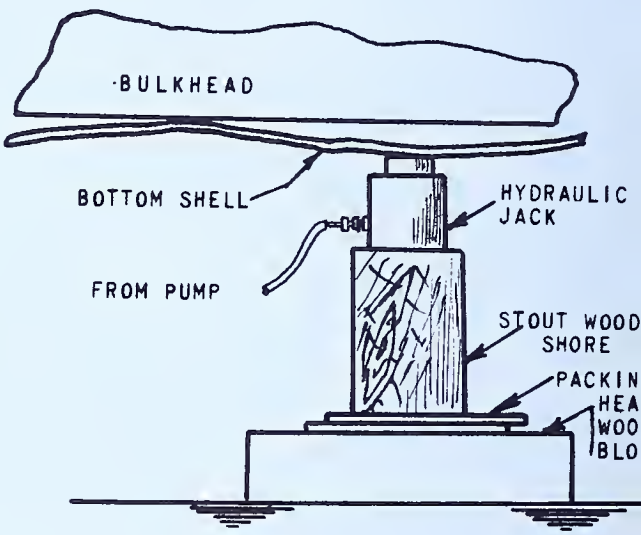


Fig. 26 -- Jacking up Bottom She

JACKING UP BOTTOM SHELL PLATES

One of the most common uses of the hydraulic jack is to push a ship's bottom shell

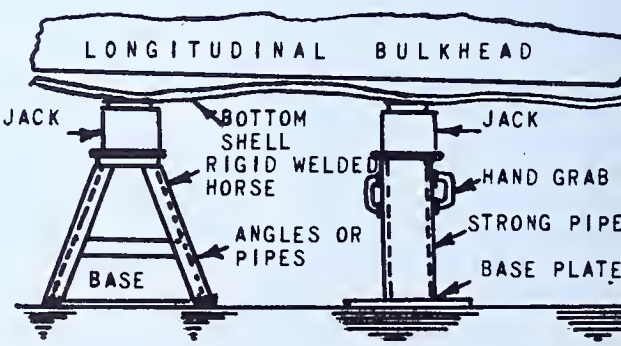


Fig. 27 -- Jack Supports under Botto Shell

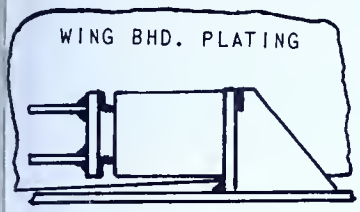


Fig. 29 — Detail of Jack Connection

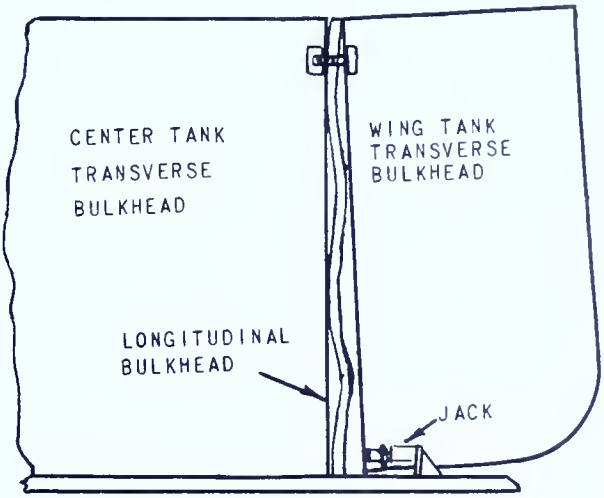


Fig. 28 -- Jacking Wing Bulkhead Into Place

plating up tight against a transverse or a longitudinal bulkhead. In this case, the only requirement is a substantial base or foundation underneath the jack.

In Fig. 26, the jack is supported by a heavy block; wide, thin boards (packing) which are used for height adjustment; and a stout wooden shore, sawed to the required length. Other possible jack supports are shown in Fig. 27.

In Figs. 26 and 27, note that the jack always is arranged so that its push is perpendicular to the bottom of the bulkhead, although either the declivity or dead rise of the ship may give the bulkhead a slope. This will prevent the piston from being racked or twisted sidewise in the cylinder, which would cause the piston and cylinder wall to wear unevenly and make the water seal inefficient.

JACKING BULKHEADS INTO PLACE

Another common use of the hydraulic jack is to push the bottom of a transverse wing bulkhead inboard to position after the top of the bulkhead has been made fast.

In Fig. 28, the center bulkhead has been set and welded to the bottom shell. The top of the longitudinal bulkhead has been pulled to the transverse center bulkhead. The wing transverse bulkhead has been erected, pulled tight at the top, and securely bolted. The edges of the transverse bulkheads should be straightened or lined, after which the jack is attached, as in Figs. 28 and 29, and the bottom of wing bulkhead pushed inboard. At the same time, the wrinkles in the longitudinal bulkhead are flattened out and both transverse bulkheads can be tacked and welded. This same hook-up can be used in various other places on the ship.

JACKING DECK DOWN TO BULKHEADS

After the longitudinal and transverse bulkheads have been welded to each other and deck sections have been erected and regulated, it is necessary to bring the deck down tight against the

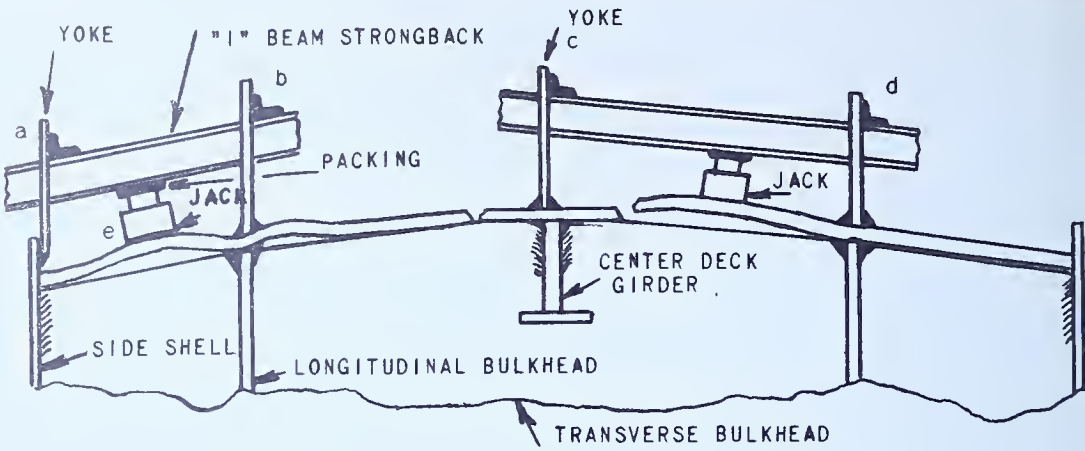


Fig.30 -- Jacking Deck Down to Bulkhead

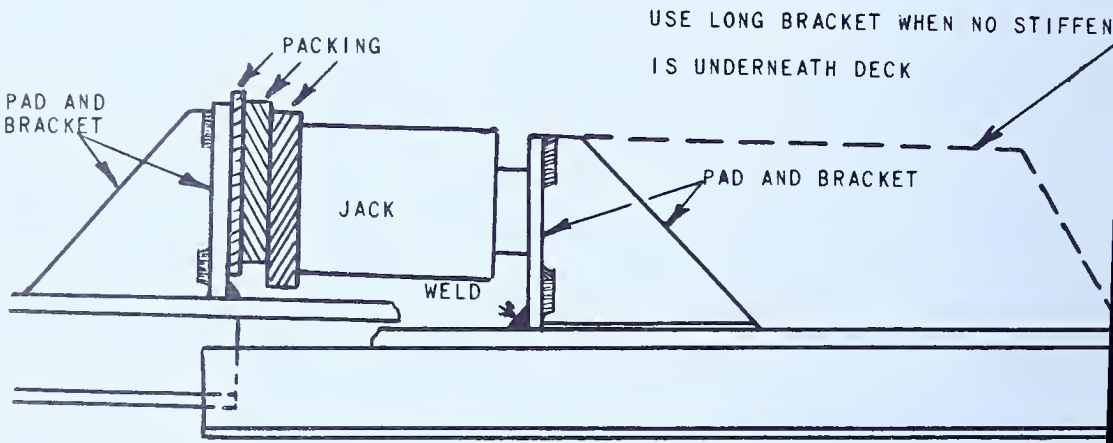


Fig. 31 -- Pushing Two Deck Sections Apart With Hydraulic Jacks

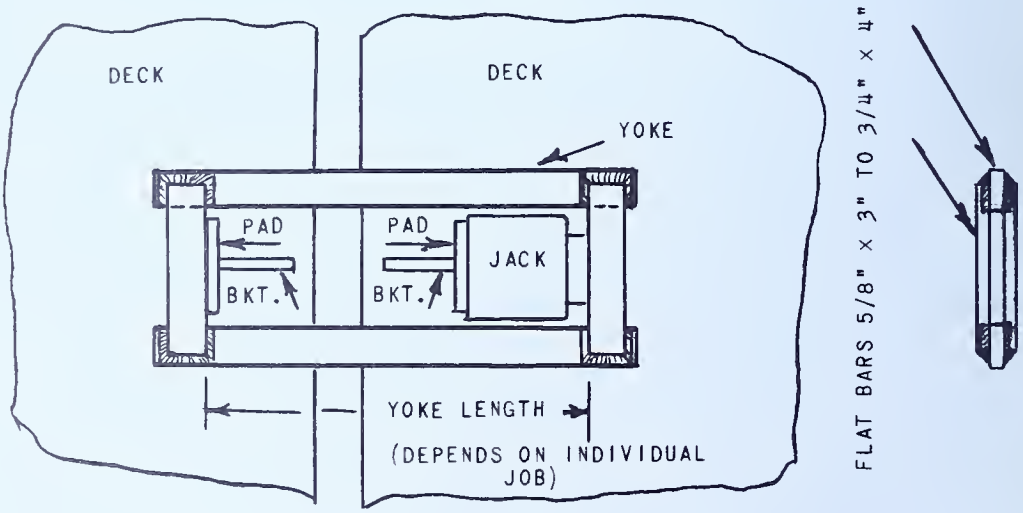


Fig. 32 -- Use of Jack and Yoke for Pulling

bulkheads. The first operation after the deck is regulated, is to pull the deck down to the longitudinal bulkhead close to the transverse bulkhead and weld it. This can be done with bolts and clips as previously explained. Yokes are then welded to the deck, as illustrated, to hold a strongback, as at "ab" and "cd" in Fig. 30.

The yoke at "a" is fastened to the side shell plating. After attaching yokes, a hydraulic jack can be placed under the strongback, as at "e", to push out the wrinkles and force the deck down to the bulkhead, where it can be tacked and welded. The strongback at "cd", as used for the center section, has one yoke over the longitudinal bulkhead and another over the welded center line deck girder.

After the deck is pushed down and welded to the transverse bulkhead, the strongbacks can be turned around and used in a similar manner to push the deck to the longitudinal bulkhead between transverses.

MOVING DECK SECTIONS WITH JACK

Another use of the hydraulic jack is in pushing or pulling of deck sections when they are being regulated. For pushing, they can be rigged as in Fig. 31, care being taken that the pad and bracket used are directly over a stiffener to prevent bending the deck plates.

Figure 32 shows in plan view how two deck sections can be pulled together with a jack and a yoke instead of a turnbuckle. The size of yoke depends upon the individual job.

Note: Location of welds should be noticed in all sketches. As far as possible, they are placed for maximum efficiency.

Pushing Deck Sections With Hydraulic Jack

Pulling Deck Sections With Hydraulic Jack and Yoke

Figure 33 shows the construction of the pad and bracket commonly used with jacks. The long bracket (shown by dash lines) is used when there is no longitudinal or stiffener on the opposite side of the plate. A few tack welds should be put on the long bracket to keep it straight.

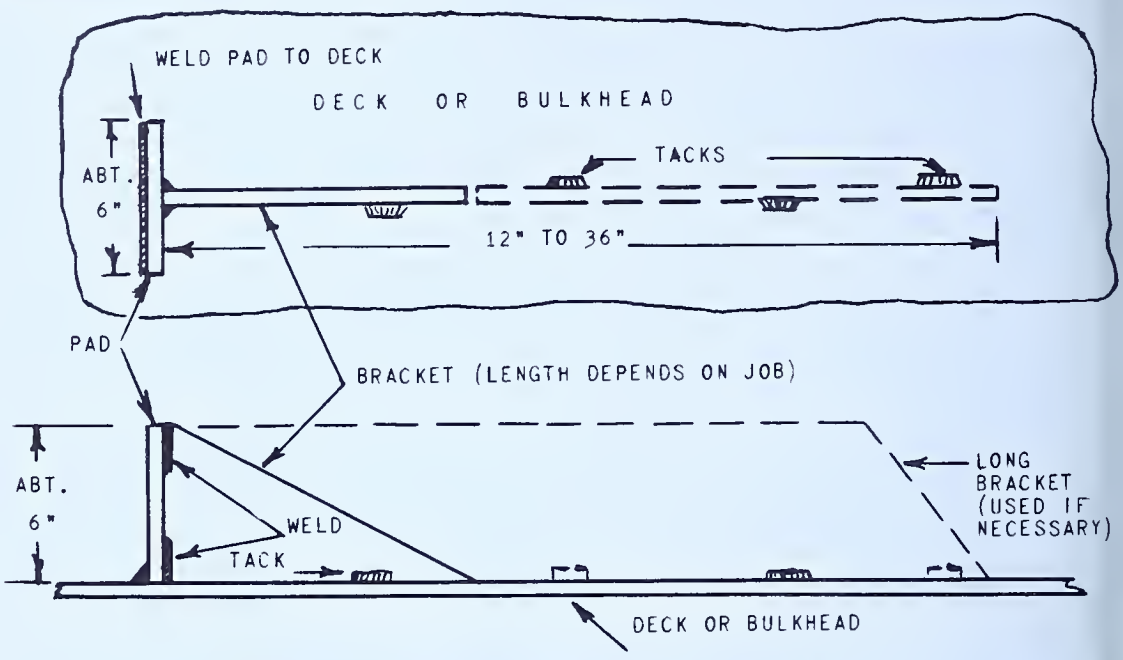


Fig. 33 -- Pad and Bracket for Use With Jack

Questions

1. What determines the amount of force exerted by a hydraulic jack?
2. Does the larger piston or the smaller piston in a hydraulic pump give the greater water pressure?
3. Why are several small tacks applied to the long bracket used behind the pad for the jack connection shown in Fig. 33?

BENDING OF PLATES AND SHAPES

When a long piece of metal of uniform rectangular cross section is forcibly bent, as in Fig. 34, the metal on the inside of the curve is shortened, while the metal on the outside of the curve "cd" is lengthened. The fibers in the short side will be in compression while those in the long side will be in tension.

If the amount of bending is not such as to exceed the elastic limit (that is, if there is no permanent set) the bar will straighten out to its original position when the external force is removed

Halfway between the edge "ab" and the edge "cd" is a surface "xx" which will not be lengthened or shortened when the bar is bent, and which will have no tension or compression forces in it. This is known as the neutral surface. It is located at the center of gravity of the cross section.

The neutral surface of a flat plate is at the center of its thickness. When plates or bars are flanged or rolled to change their shape, the length of the neutral surface remains the same. When beams or stiffeners of other than rectangular cross section (such as channels, angle bars, flanged plates, etc.) are bent, the neutral surface is still at the center of gravity of the section, but not necessarily halfway between the inside and outside of the curve. For example, the neutral surface of the Tee-bar in Fig. 35 is located close to the flange as shown at "xx".

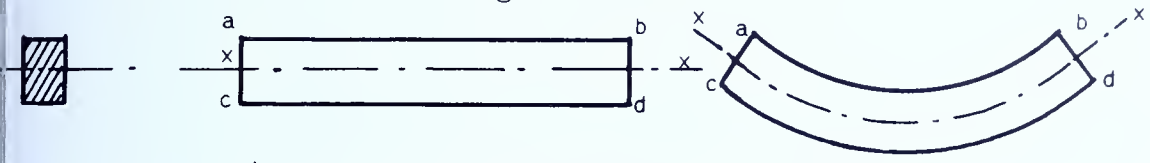


Fig. 34 -- Bending Rectangular Sections

After bending, the metal along the neutral axis will still not be lengthened or shortened. The flange at "ab" will be shorter when bent and the edge "cd" will be longer. When a bar of any section is riveted or welded to a bulkhead or other plating, the neutral surface of the bar will move toward the plate, because of the effect of the plate in resisting any expansion or contraction. The plating acts the same as a large flange. In Fig. 36, the neutral surface of the combined angle bar and plate would be approximately as shown at "xx". If the stiffener were a riveted channel rather than a welded angle, the effect of the plating would be similar.

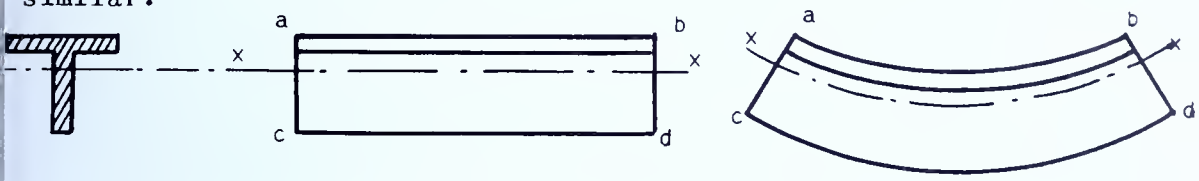


Fig. 35 -- Bending a T-Bar

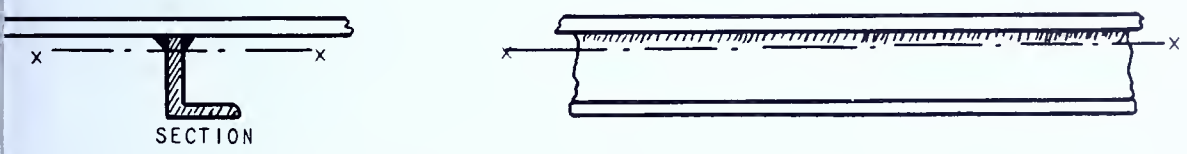


Fig. 36 --Neutral Surface of Combined Plating and Stiffener

If any of the preceding bars were to have one edge (such as "ab" in Fig. 37) *shortened or contracted* in any manner, the bar would bend up as though an outside force had been applied. Any shortening effect on the opposite side of the neutral axis (as at "cd") would tend to bend the bar in the opposite direction. *Stretching or expanding* either "ab" or "cd" would have the reverse effect on the curvature of the bar.

Curvature caused by expanding and contracting of the metal is an important consideration in the heating or welding of structural members.

Questions

1. What is meant by the "neutral surface" of a plate?
2. Where is the neutral surface of a welded plate and stiffener located?

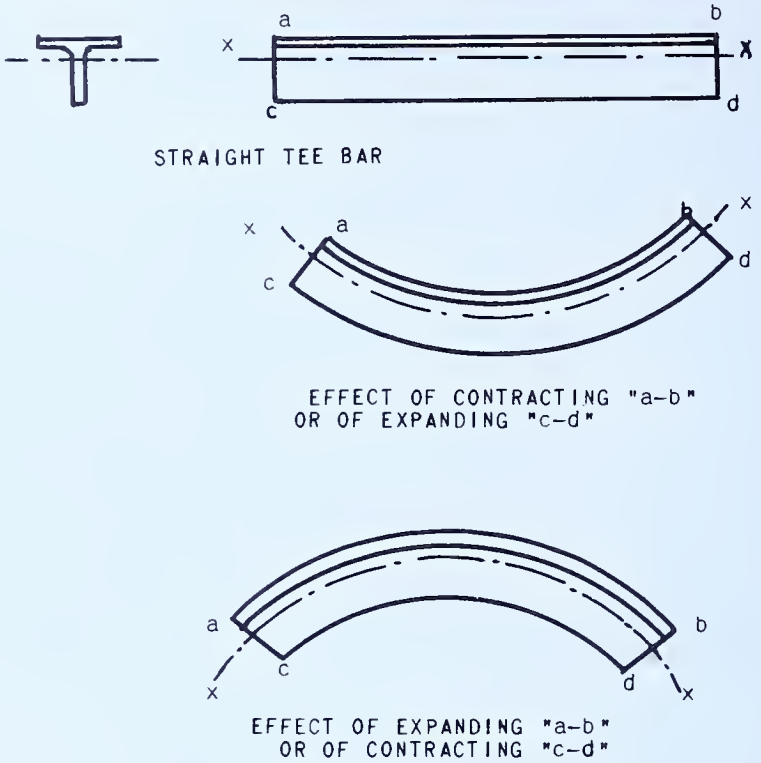


Fig. 37 — Effect of Expansion and Contraction at a Distance From the Neutral Axis

WELDING CONTRACTION AND DISTORTION

Metals expand when heated and contract when cooled. When two pieces of steel are electrically welded together, a very large amount of heat is liberated at the joint. This causes the metal to become soft and plastic close to the arc and to expand, or lengthen, for some distance from the arc. As the weld begins to cool, the plastic metal first hardens and then contracts. The amount of contraction depends on the amount of weld metal and whether the two pieces of steel are free to move. For example, take an ordinary butt weld for a flat deck, as made manually on the ship, Fig. 38. Before welding, the plates are as shown at (A) and are fastened (restrained) by means of tack welds. The welder then starts his first bead at the narrow part of the Vee as shown at "ab" in Fig. 38, detail (C).

With successive beads the welder builds up the joint to "cd". The lower part of the weld at "ab" has a small amount of con-

traction, since the amount of weld metal at that spot is small, being in the narrowest part of the groove. As the weld grows higher, the groove gets wider, and the longitudinal contraction of the plates (*across* the weld) is therefore greater. Owing to this greater contraction of the top of the weld, the top surface of the plates will be shorter than the bottom surface. This will cause the plates to be dished locally in way of the weld as at (B), Fig. 38. The backing bead, which is put on underneath after the heavy part of the weld is finished, is not large enough to reduce the distortion of the joint appreciably.

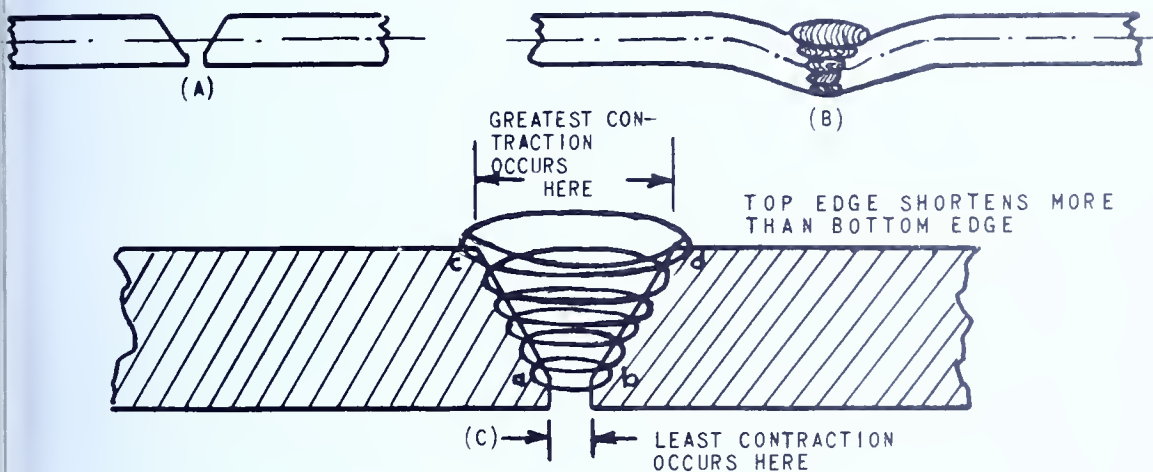


Fig. 38--Single Vee Butt Weld

In the double-Vee butt joint, the distortion is less than in the previous type (see Fig. 39). This joint often is used for side shell plating where no overhead welding is required. Here half the weld is inside and half is outside. Before welding, the plates are as shown in detail (A). Then one side "abcd" of the joint is welded and the distortion is as shown in detail (B). When the other side "abef" is welded, the contraction at "ef" will

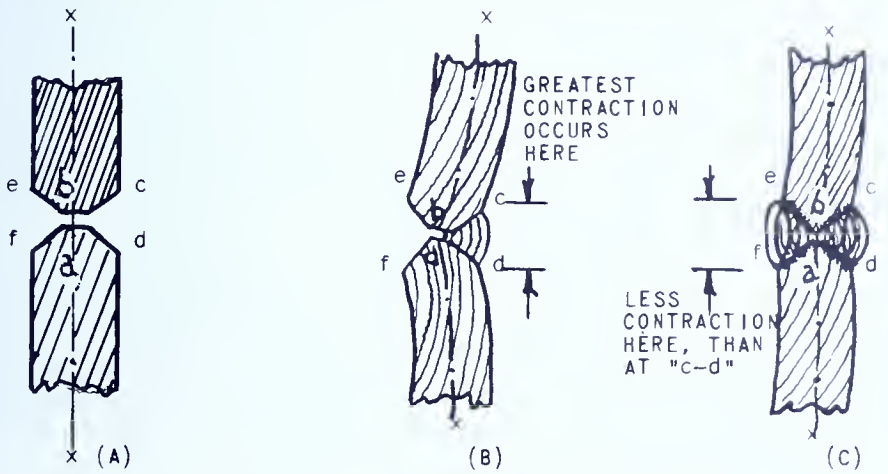


Fig. 39--Double Vee Butt Weld

tend to straighten the joint, but because the other side is restrained by the first weld, the plates will not quite come back to their original position. The joint will remain slightly distorted as at (C) in Fig. 39.

The plain Tee joint is used to fasten the edge of one plate to the side of another, as shown in Fig. 40. This type of joint connects bulkheads to shell and deck plates, web frames to shell plates, deck plates to shell plates, etc. The plates should be

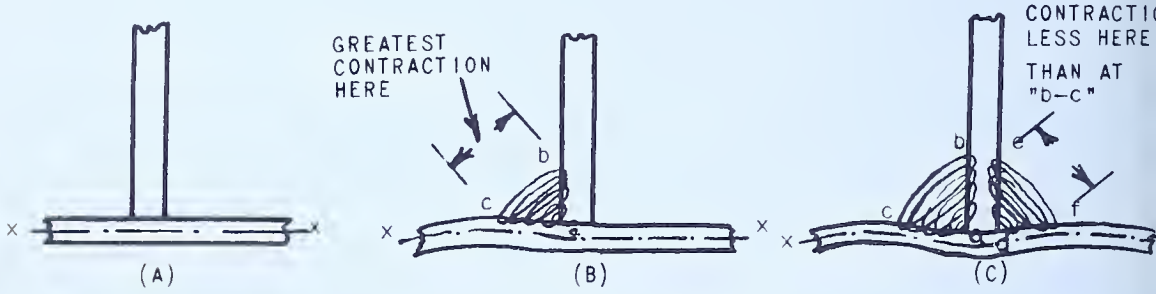


Fig. 40--Plain Tee Joint

tight together before the first fillet is started, as in detail (A). After completion of the first fillet "abc" the lower plate is distorted as in detail (B), owing to the large contraction across the weld at "bc". When the second, or opposite fillet weld "def" is finished, the lower plate is dished as shown in detail (C). The upper plate usually is not distorted when the weld is completed, but will be forced very tightly against the lower plate, owing to vertical contraction (along "ab" and "de") in the weld metal. When for any reason access can be had to only one side of the plate, a single-Vee Tee joint can be used. This is sketched in Fig. 41. Detail (A) shows the plates before the weld is started. Detail (B) shows the distortion of the lower plate when the weld is completed. The lower plate in this case is dished less than in the plain Tee. This weld often is used for open work; that is, where the two plates are not close together before welding.

Distortion Resulting from Welding Plates to Frames

The double-Vee Tee joint, as sketched in Fig. 42, is used for heavy plates where it is possible to weld both sides and where a heavy load is expected. Detail (A) shows the plates before welding and the final distortion is as shown at (B). The longitudinal contraction of welds, while not as

troublesome as the transverse contraction of welds, does cause bending and wrinkling of the ship's structural members, such as bulkheads and various stiffeners. Suppose a single rectangular plate has a fillet weld around all four sides, as in the case of a short partition bulkhead between two other bulkheads. Fig. 43 shows the plate welded to the deck above at "ab", to the deck be-

Fig. 41 -- Single Vee Tee Joint

Fig. 42--Double Vee Tee Joint

low at "cd", and to the bulkheads at "ac" and "bd". The effect of the cooling and contraction along the length of these welds will be to shorten the four sides of the bulkhead and leave the *center bulged out* on one side or the other. The remedy for this situation will be explained later.

If, instead of a single plate, the bulkhead is built up of several plates and stiffeners all welded in place before erection, the middle portion of the bulkhead will be tight owing to the contraction in both directions caused by the butt welds and fillet welds. When this bulkhead is erected and the edges straightened for welding, there will be compression all along the boundaries of the bulkhead. The contraction of the weld will tend to shorten the edge, but since the edge was already in compression, the contraction will merely bring it back to the condition of the rest of the bulkhead, so that there will be little or no bulge.(See Fig. 44.)

Shell longitudinals, deck longitudinals, and bulkhead and other stiffeners are distorted to some extent by the longitudinal contraction of their welds. As explained previously, the effective neutral surface of a combined stiffener and plate (such as a bulkhead) is approximately as shown in Fig. 45. The welding contraction causes a bow in the stiffener and therefore in the bulkhead. Stiffeners made of angles, Tee-bars, flanged plates, and other sections behave in the same manner when welded to a plate.

Owing to the contraction of welds when cooling, as previously

described, there is in every welded structure a certain amount of distortion or unfairness, which in many cases must be reduced (as explained later), in order that the structure may present a more pleasing appearance. However, the process of heating and shrinking, if carried to excess, will impair the quality of the steel. The fairing should therefore be stopped as soon as the appearance is satisfactory. The table of tolerances on the following page has been prepared from the specifications of vessels for the United States Navy. Figures quoted in this table show allowable unfairness *per panel* for deck, shell, and bulkhead plating. For bulkheads not mentioned, an unfairness of 1" per panel will be permitted.

Where straightening of structure is required, it shall be postponed as long as practicable during the building period, so that one operation will suffice.

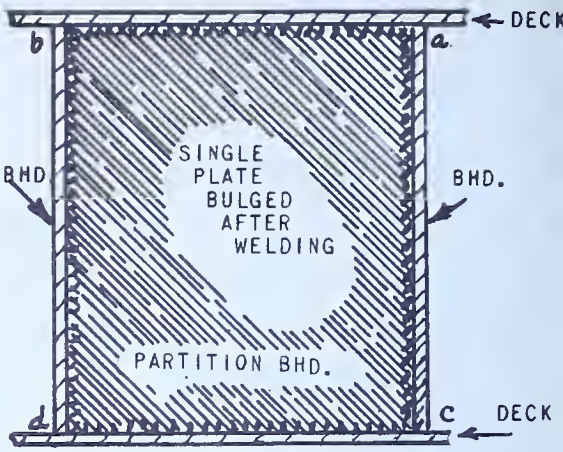


Fig. 43--Plate Welded All Around

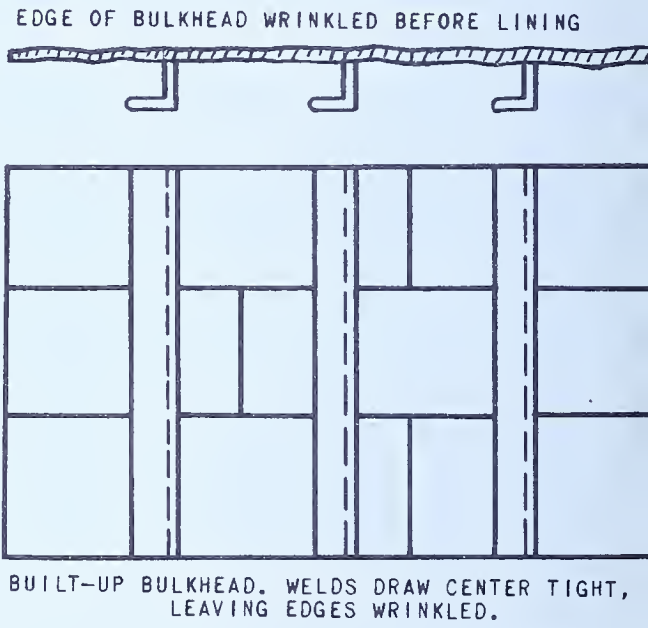


Fig. 44--Bulkhead of Welded Construct Before Boundary is Welded

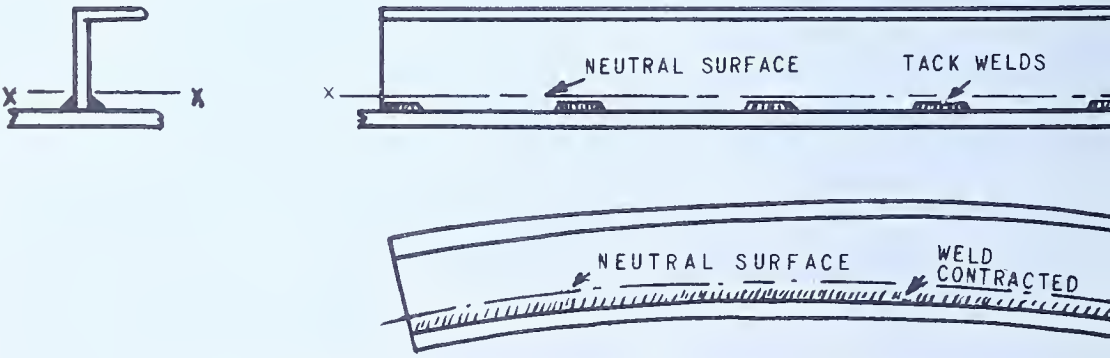


Fig. 45--Bow in Bulkhead Stiffeners Caused by Contraction of Weld Below Neutral Surface

Table VI -- Tolerances for Fairness of Welded Structures (Compiled from "Specifications for Welding" Vessels for the United States Navy)

Spacing of Stiff., Frs. or Beams	Living Quarters			Deck Plating				Shell Plating			
	A			B				C			
48"	1/2	7/16	7/16	1/2	3/8	3/8	3/8	3/8	5/16	5/16	1/4
46"	1/2	7/16	7/16	1/2	3/8	3/8	3/8	3/8	5/16	5/16	1/4
44"	1/2	7/16	7/16	1/2	3/8	3/8	3/8	3/8	5/16	5/16	1/4
42"	1/2	7/16	7/16	1/2	3/8	3/8	1/4	3/8	5/16	1/4	1/4
40"	1/2	7/16	3/8	1/2	3/8	3/8	1/4	3/8	5/16	1/4	1/4
38"	1/2	7/16	3/8	1/2	3/8	1/4	1/4	3/8	5/16	1/4	1/4
36"	1/2	7/16	3/8	3/8	3/8	1/4	1/4	3/8	1/4	1/4	3/16
34"	1/2	3/8	3/8	3/8	3/8	1/4	3/16	5/16	1/4	1/4	3/16
32"	1/2	3/8	3/8	3/8	1/4	1/4	3/16	5/16	1/4	3/16	3/16
30"	7/16	3/8	5/16	3/8	1/4	3/16	3/16	5/16	1/4	3/16	3/16
28"	7/16	3/8	5/16	3/8	1/4	3/16	1/8	5/16	1/4	3/16	3/16
26"	7/16	5/16	5/16	1/4	3/16	1/8	1/8	1/4	3/16	3/16	3/16
24"	3/8	5/16	1/4	1/4	3/16	1/8	1/8	1/4	3/16	3/16	1/8
22"	3/8	5/16	1/4	3/16	1/8	1/8	1/16	1/4	3/16	1/8	1/8
20"	5/16	1/4	3/16	1/8	1/8	1/16	1/16	3/16	1/8	1/8	1/8
18"	1/4	3/16	3/16	1/8	1/16	1/16	1/16	3/16	1/8	1/8	1/8
Thickness of Plates	3/16	1/4	3/8	1/4	3/8	1/2	5/8	3/8	1/2	5/8	3/4

For bulkheads not mentioned, an unfairness of 1" per panel will be permitted.

The unfairness of welded plating shall not exceed the tolerances shown in the above table. In applying the above tolerances, the unfairness of the plating shall be measured across the minor dimension of the panel.

Questions

1. Explain the cause of welding distortion.
2. Why does a double-Vee butt weld distort less than a single-Vee butt weld?
3. Why does a butt weld contract more across the weld than lengthwise?
4. Why are panels in welded bulkheads bulged after welding?

LINING AND TACK WELDING BOTTOM SHELL ASSEMBLY

To determine the location, size, and spacing of tack welds the various hull members, it is necessary to make use of past perience and experiments. The tacks must be close enough strong enough to resist any tendency to shear off or tear ap when the final welding begins to contract. In deciding upon order in which the different members are to be lined and tacked very important consideration is the fact that a weld contra

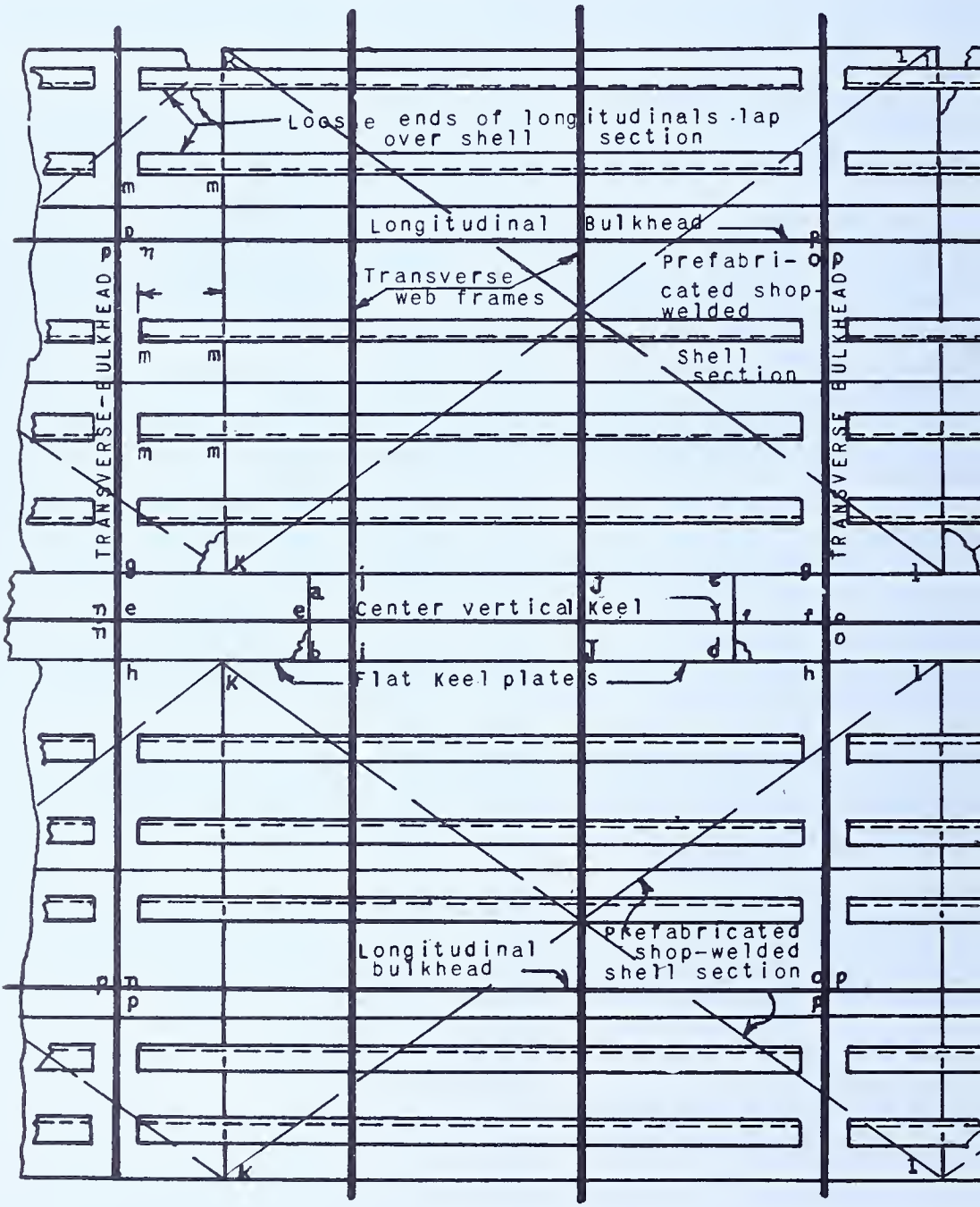


Fig. 46 — Plan View of Shell Bottom

much more across its width (transversely) than it does in a lengthwise direction.

Before the operation of lining and tacking begins, the sections of the ship must have been erected and regulated, or aligned, in exactly the proper position with regard to the center line, base line, etc. In lining and tacking it is extremely important that the movement of any structural member, from its correct location, be minimized.

In Fig. 46 is shown a plan view of a part of the bottom shell assembly used on an ordinary longitudinally-framed, all-welded tanker. *The sections shown have been regulated and now are ready to be lined and tacked.*

Steps in Lining and Tacking a Bottom Shell Section

PROCEDURE: (This procedure will vary with different types of ships)

1. Line and tack the transverse butts of the flat keel plate ("ab" and "cd", Fig. 46).

   This must be done symmetrically about the center line of the ship; that is, if a tack weld is placed at "a", a tack weld should be made at "b" at the same time, or immediately afterward. If this method is not carefully followed, a number of consecutive welds on one side will tend to draw one or two of the keel plates out of line, causing much difficulty. The size and spacing of the tacks required can be found in *Table VII*

2. Line and tack the bottom edge of the vertical keel where it was not welded in the shop (see "ee" and "ff").

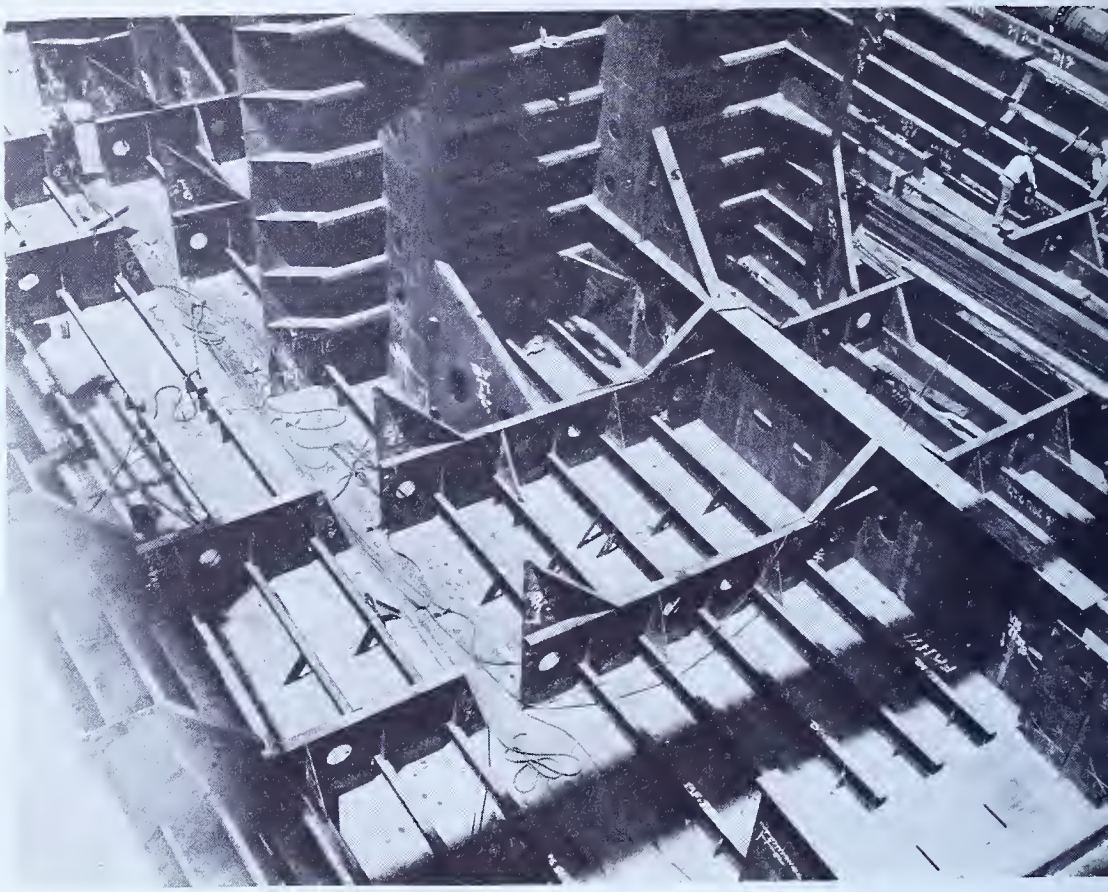
   The part between the flat keel butts shown will have been lined and tacked in the shop before erection. Note that this longitudinal tack weld is made *after* the transverse butt weld.

3. Line and tack the longitudinal seams between the flat keel plates and the shop-welded bottom sections. ("gg" and "hh", Fig. 46).

   It is preferable for one man to work on the port side while another works on the starboard side. They should work *directly opposite* one another so that there will not be a tendency to pull the flat keel plate out of line either way.

4. Line and tack the short loose sections of the transverse web frames to the flat keel plate ("ii" and "jj", Fig. 46).

   Notice that the bottom shell section (as denoted by two diagonal dashed lines from its corners) is completely assembled in the shop before erection. Shell plates, shell longitudinals, and transverse web frames have been welded in place, so that no additional contraction can be expected from them. The plates around the edge of the section have been trimmed until the section itself has the proper outside dimensions. (Stock had been left on the plates for this purpose) The only portions of the frames and longitudinals which need to be lined and tacked are those which extend over the adjacent shell sections.



Bottom Shell Assembly

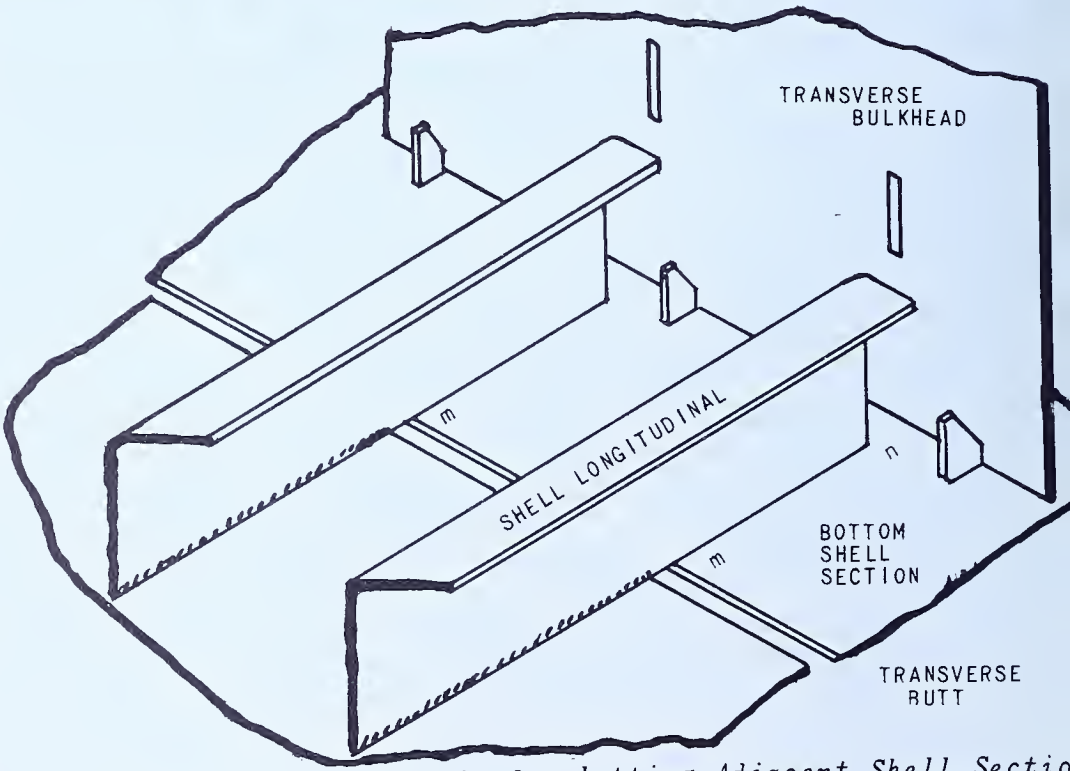


Fig. 47 — Longitudinals Overlapping Adjacent Shell Sectio

5. Tack the transverse seams at the forward and after edges of the bottom shell sections ("kk" and "ll", Fig. 46).

   Here again the port and starboard sides should be worked simultaneously.

6. Line and tack to the plating of one shell section the loose ends of the longitudinals from the adjacent shell section ("mm", Fig. 46).

   Here, as always, the heavy contraction across the butt weld is allowed to occur before the stiffening members which cross the butt are tacked, avoiding a buckling of the stiffener. It should be noted, however, that when the final weld is later applied to this butt the further contraction often makes it necessary to cut the longitudinals loose and re-line and tack them.

7. Line and tack the transverse bulkheads to the bottom shell plating ("nn" and "oo", Fig. 46).

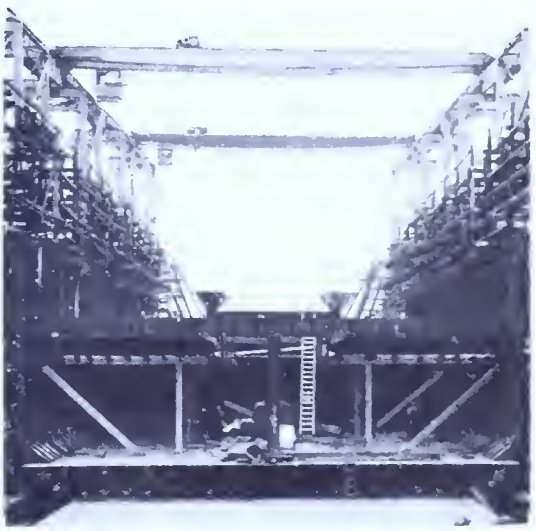
   Note that the regulators always set the *center* of this bulkhead at the bottom. The tack weld at this point should not be cut loose. If necessary, the outboard ends of the bulkheads may be freed to allow big wrinkles to work themselves out. Never cut loose any tacks made by regulators until enough additional tacks are put on to hold the members in position.

8. Line and tack the vertical connections of the transverse bulkheads to the longitudinal bulkheads, both inboard and outboard.

   These connections are denoted by the letter "p" in the sketch. *Note:* Tack welds which fasten bulkheads to bulkheads, or bulkheads to decks, should, wherever possible, be placed intermittently on both sides of the bulkhead.

9. Line and tack the framing outboard of the longitudinal bulkhead, except the lapped joints in the big web frames. (The latter are fastened only with erection bolts until the other members are welded).

The sequence of tack welding as thus explained applies in principle to deck sections and side shell sections throughout the ship, although local conditions often will cause variations. The important point is that each butt should be tacked before the stiffeners which cross it are tacked. This prevents buckling of the stiffeners which otherwise would be caused by contraction of the butt weld.



Transversely Framed Ship Under Construction

Questions

1. What is meant by a "bottom shell section"?
2. Why should a plate butt be tacked before the stiffeners whic cross it are tacked?
3. Why may procedures employed in lining and tacking a botto shell assembly vary from ship to ship?
4. Why should tacks made by regulators not be cut loose befor being replaced by other tack welds?
5. In the photograph on page 30 identify the following hull mem bers: (a) bottom shell plating; (b) vertical keel; (c) trans verse web frames; (d) shell longitudinals; (e) transverse bulk head.

PRACTICAL HINTS ON LINING AND TACKING

TAPERED BUTT

Figure 48 illustrates a typical condition which frequently encountered in lining butts in shell or deck plating. In th figure, plates "A" and "B" have been regulated and tacked with much wider opening at "d" than at "c".

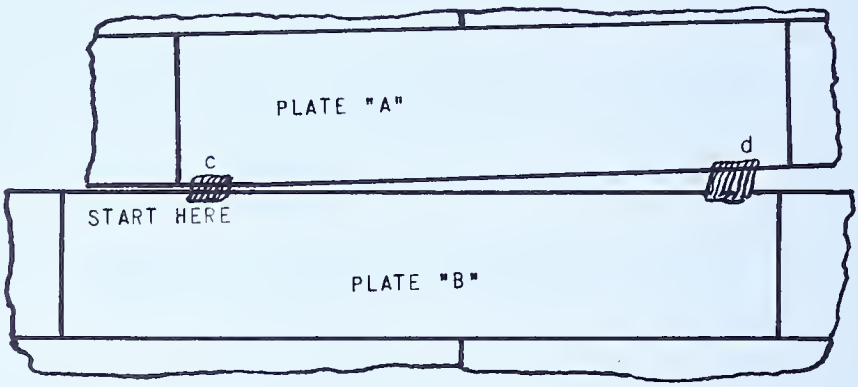


Fig. 48 -- Tapered Opening for Butt Weld

Start lining and tacking at "c", where the opening is narro working toward the other end of the butt. This will tend to clo the open end as the successive tack welds contract, and by t time the tacker gets to the end at "d", the opening in the bu will be nearly uniform, and no burning will be required. If t tacker had started at the wrong end "d" and worked toward t left, contraction would have pulled the plate still tighter t gether at the narrow end "c" and possibly half the plate wou have had to be burned to get the required clearance.

ONE PLATE HUMPED

Two plates "A" and "B" in Fig. 49 are to be lined and tack for a butt weld. The tacks at "c" and "d" were put on by the reg lators. The first plate "A" is tight and straight while the seco

plate "B", being slightly longer, has a hump in it. The best method of lining is to dog down the center of the plate (at "e") and tack it firmly. This will leave two smaller humps, one on each side of the center, as shown in Fig. 50. The weld at "c" can then be burned out, allowing the butt from "e" to "c" to be dogged together, starting at "e" and working the excess metal toward the end.

The tack weld at "d" can then be cut, and the butt flushed and tacked from "e" to "d". Care should always be taken to work the excess metal toward a loose end, when this is possible.

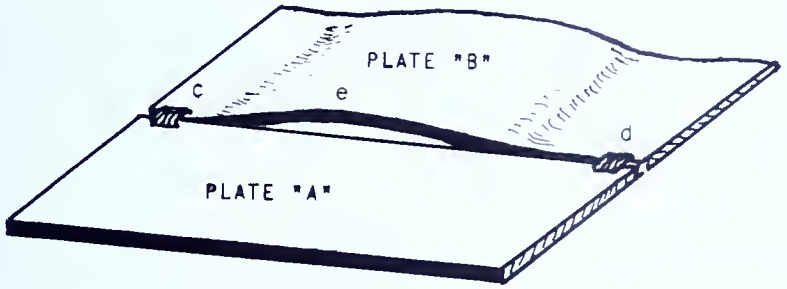


Fig. 49 -- Humped Plate Adjacent to Straight Plate

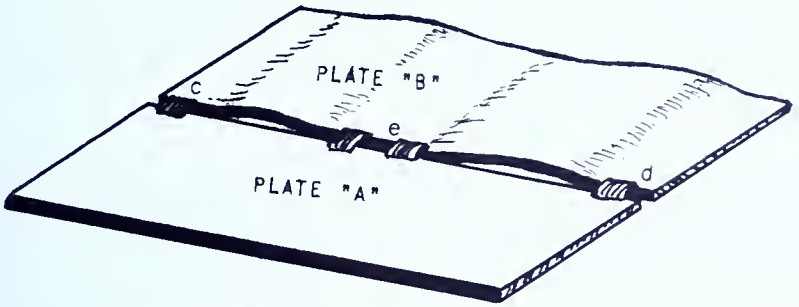


Fig. 50 -- Plates After Being Dogged and Tacked at Center

WRINKLED BULKHEAD

In Fig. 51 is illustrated an example in which a bulkhead has been set to its marks on a deck at its center and two ends, but is wrinkled between the center and the ends. Tack welds are shown at "a", "b", and "c". To take out the wrinkles, the tacker should start at "b" and line up the middle part of the bulkhead until there are plenty of tacks to hold it in position. (See "d" and "e" in Fig. 52). The tacks at "a" and "c" are then burned or chipped off and the excess metal worked toward the ends.

WIDE AND NARROW BUTTS

A common condition is shown in Fig. 53. Between plate "A" and plate "B" is a wide butt "de", and between plate "B" and plate "C" is a narrow, or tight butt "fg". All the plates are assumed to be constrained, because they are tacked to the rest of the deck plating by regulators.

The correct procedure is to first line and tack butt "
The contraction of these tacks partly closes the opening bet
plate "A" and plate "B", and at the same time draws plate
slightly away from plate "C". Both of these results will ten
prepare the butts for better welds.

If butt "fg" were first lined and tacked, the contractio
the weld would draw plates "B" and "C" tighter, and at the

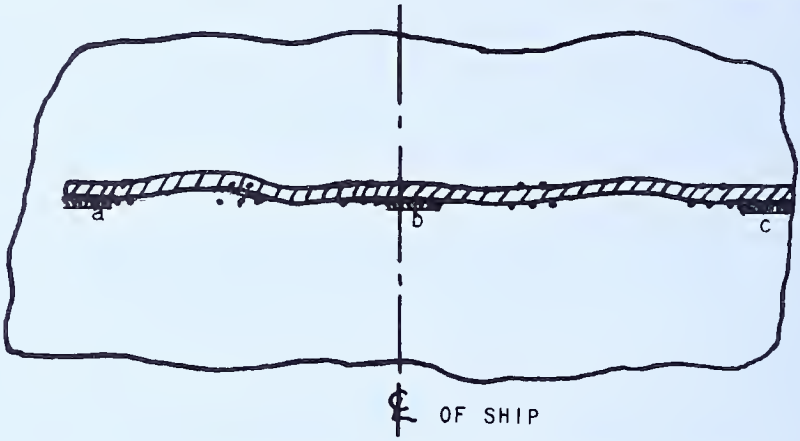


Fig. 51 -- Plan View of Wrinkled Bulkhead Connection

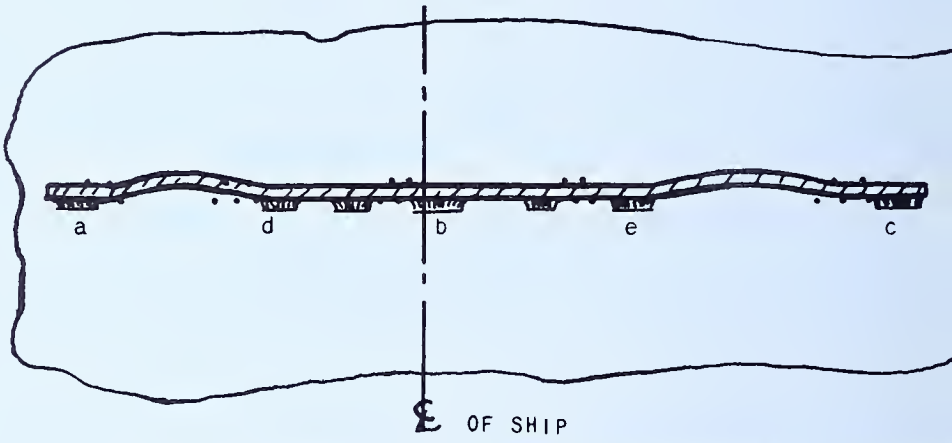


Fig. 52 -- Bulkhead With Middle Part Straightened and Tacke

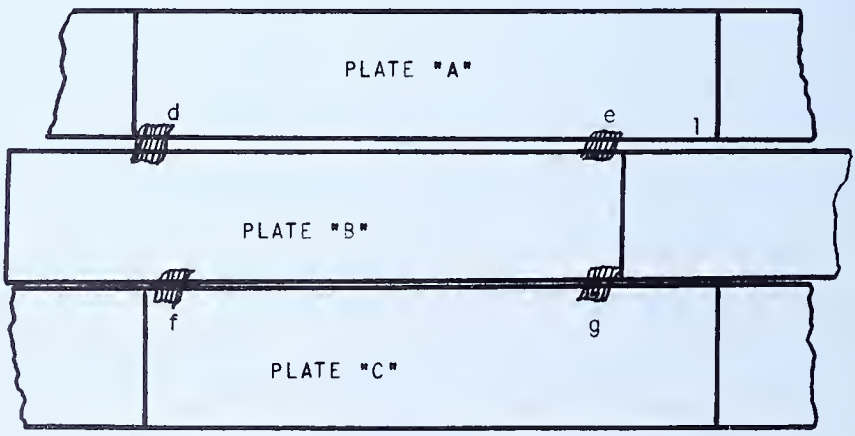


Fig. 53 -- Wide Butt Adjacent to Narrow Butt

time, would tend to draw plate "B" still farther from plate "A". Neither butt would then have the correct clearance for welding.

VARIATIONS

It must be remembered that although in the majority of cases the preceding methods should be used, there are many local conditions which change the procedure in individual cases. Experience will determine the best and most efficient way to do the job.

APPEARANCE

For the sake of appearance, dogs and clips should be applied inside of shell plates and on the stiffener side of bulkheads whenever possible. When a dog has been welded on and knocked off, or burned off, it is very difficult to remove the marks made by the weld. Inside the shell, such marks would not be as noticeable as if they were outside, since the smooth flat surface is broken by stiffeners.

Questions

1. When lining and tacking a plate butt having a tapered opening, why is it advisable that the work be started at the wide end of the butt?
2. Why should one begin at the center of the butt in lining and tacking the two plates shown in Fig. 49?
3. Why is it preferable that dogs and clips be applied to the inside of shell plates?

BUTT CLEARANCES AND TACK WELD DATA

When two flat plates are to be connected with a butt weld, a certain clearance is required before starting the final weld. It is important to be certain that there is sufficient clearance between plates, and that they are flat, as shown at "A" in Fig. 54. If one plate has too much stock the plates will overlap, or be humped, as at "B". In either case one plate must be burned to obtain proper clearance and to allow the butt to flatten out. The clearance required depends on the type of butt and also on the thickness of the plating. Standard clearances are given in Fig. 55. After the butts are regulated, and before they are tacked, it is not objectionable to have a clearance as much as 1/16" greater than that specified in Fig. 55, since the transverse contraction of each butt while being tacked will reduce the clearance.

In Fig. 56 two plates, each ½" thick, are to be joined by a single-Vee butt weld. By referring to Table VI, it is seen that the length of each tack is to be 3" and that tacks are to be

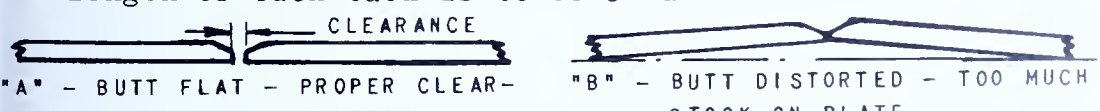


Fig. 54 -- Necessity for Butt Clearance When Tacking

spaced 12" end-to-end. Two beads are needed in building up eac tack weld.

Caution: At a plate corner, such as "x" or "y" in Fig. 56, tack should *never* be placed in the shape of a "T" or cross. Almos invariably, if this is done, a part of the "tack" weld will b broken at final welding of the plate and therefore must be chip ped out and re-welded. Tacks spaced as shown in Fig. 56 will no be broken. They are kept about 6" from the intersection of any tw butts.

USE OF TABLE VII (B)

A certain ship's bottom shell plating is stiffened by 10" x 4" flanged plate longitudinals as in Fig. 57. Referring to Table VII (B), we find that a 10" longitudinal requires 5/16" fillet tack welds, 3" long, and spaced 12" end-to-end.

Since there must be a tack-weld at the end of every stiffener, it often is necessary to de-

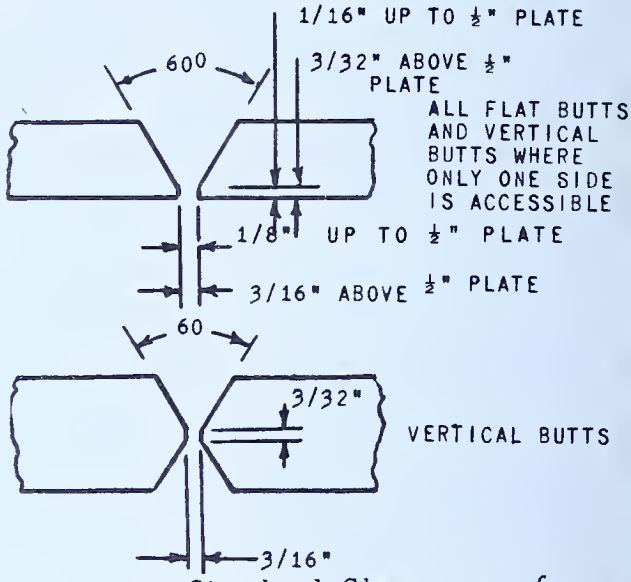


Fig. 55 -- Standard Clearances for Manual Butt Weld

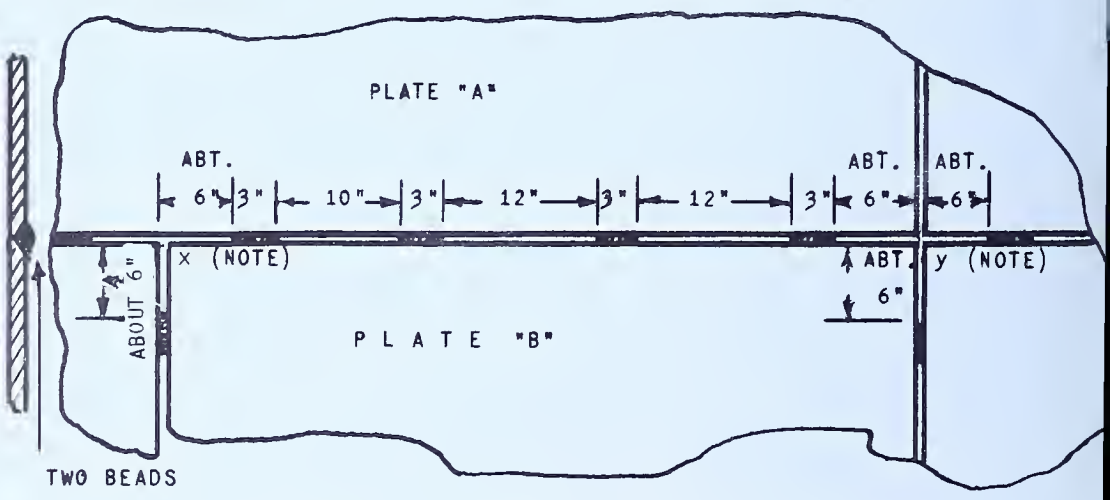


Fig. 56 -- Tack Weld Spacing for ½" Butt

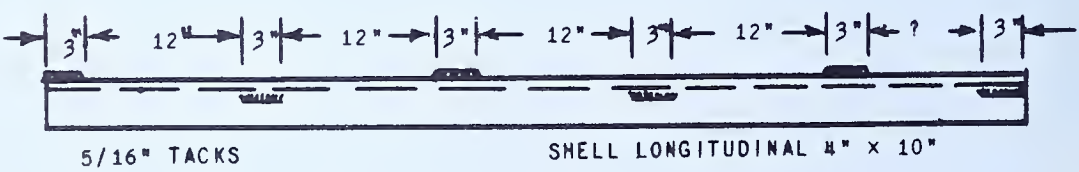


Fig. 57 -- Tack Weld Size and Spacing

Table VII -- Minimum Tack Weld Sizes and Maximum Spacing for Lining and Tacking Work

(A) Single-Vee and Double-Vee Butts

Plate Thickness	Number of beads	Length of tacks	Distance btwn. tacks
Plates up to 3/8"	1	3"	12"
Plates 7/16" to 5/8"	2	3"	12"
Plates 11/16" & up	3	3"	12"

(B) Stiffeners and Longitudinals

	Size of Fillet W.	Length of tacks	Distance btwn.tacks
Up to 5" Longls.	3/16" or 1/4"	3"	12"
6" to 9" Longls.	1/4"	3"	12"
10" or over Ls.	5/16"	3"	12"

(C) For Bulkheads

	Size of Fillet W.	Length of tacks	Distance btwn.tacks
Up to 5/16" Plt.	3/16" or 1/4"	3"	12"
Plates 3/8" & up	5/16"	3"	12"

Chipping a Seam

crease the space between the last two tack welds (7" in this ample). The specified distance between two tack welds should be increased.

In a great many cases, owing to local conditions, more tacks heavier tacks than specified will be required to hold the steel place. In general, if an excessive amount of force is needed get the members lined up, more tacks will be required than specified in the preceding tables.

Questions

1. What is the standard clearance for a single-Vee butt weld joing a 3/8" plate to a 1/2" plate?
2. What is the standard clearance for a double-Vee butt weld joing two 5/8" plates?
3. What is the difference between a flanged plate and an ang
4. What is the required tack weld size and maximum spacing on a longitudinal or stiffener?

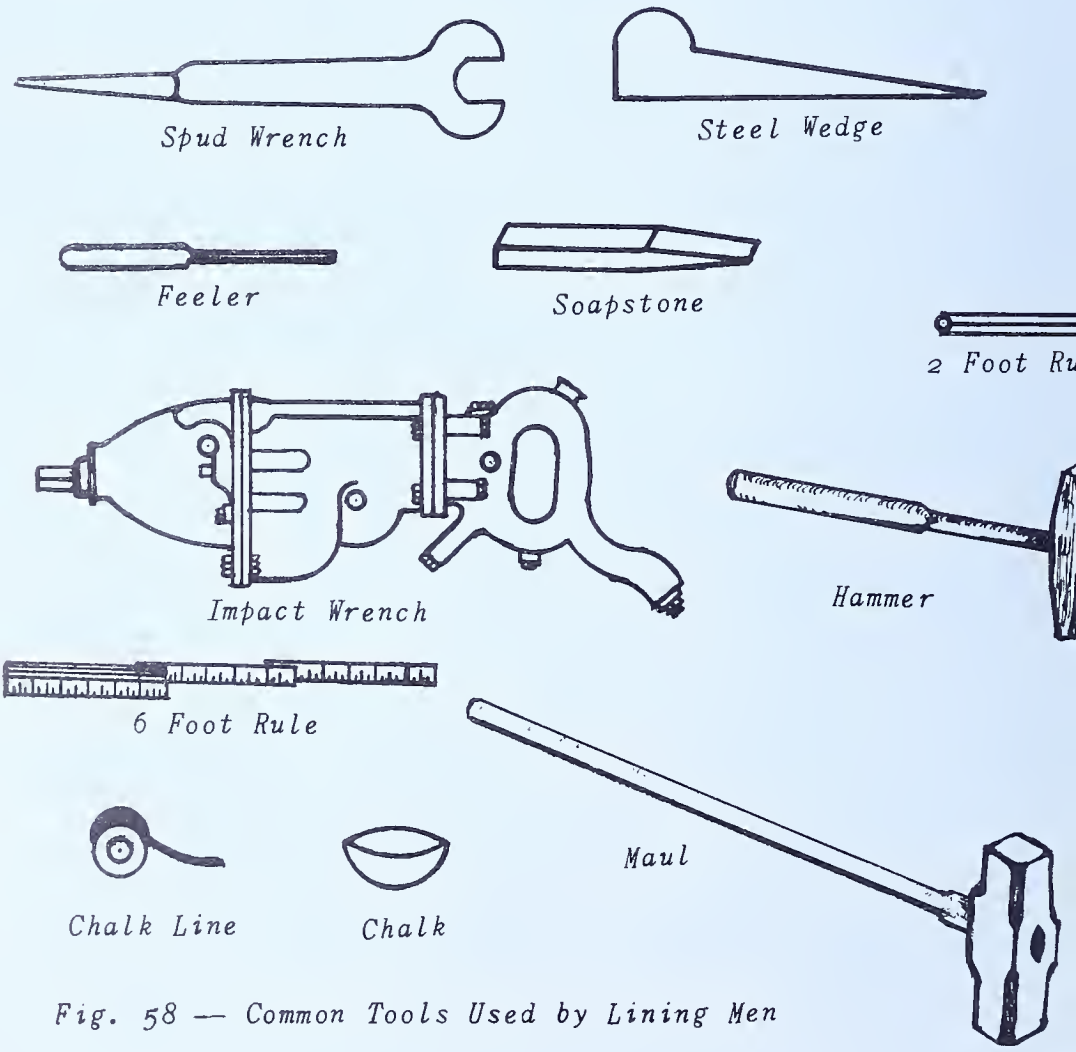


Fig. 58 — Common Tools Used by Lining Men

PART II

Lifting and Installing Liners, Angles, Brackets, Collars, and Spacers

USE OF LINERS

Liners are pieces of steel, used to fill the spaces caused by frames, plates or other members crossing a plate edge when none of the members are joggled or offset to eliminate these spaces.

PARALLEL LINERS

At "A" in Fig. 59 is shown a parallel liner; that is, a liner

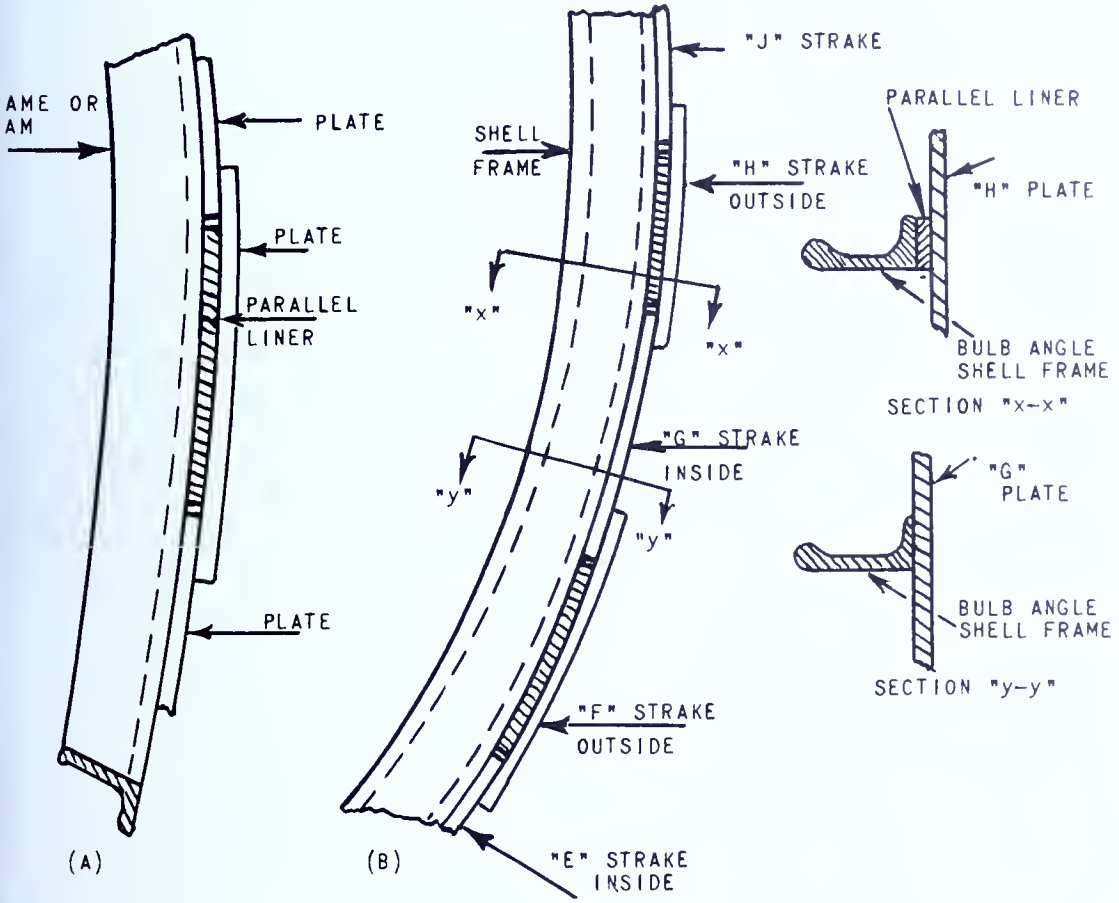


Fig. 59 -- Parallel Liners

of constant thickness. Such liners are commonly used for she frames and deck beams where the strakes are arranged in an "in a out" fashion as at "B" in Fig. 59.

The section "xx" shows the liner in way of the "H" strake whi is outside; that is, the "H" strake laps on the outside of t plate below and the plate above. Section "yy" shows the "G" pla (which is inside) close against the frame, so that no liner needed.

Parallel frame liners such as these are generally not wate

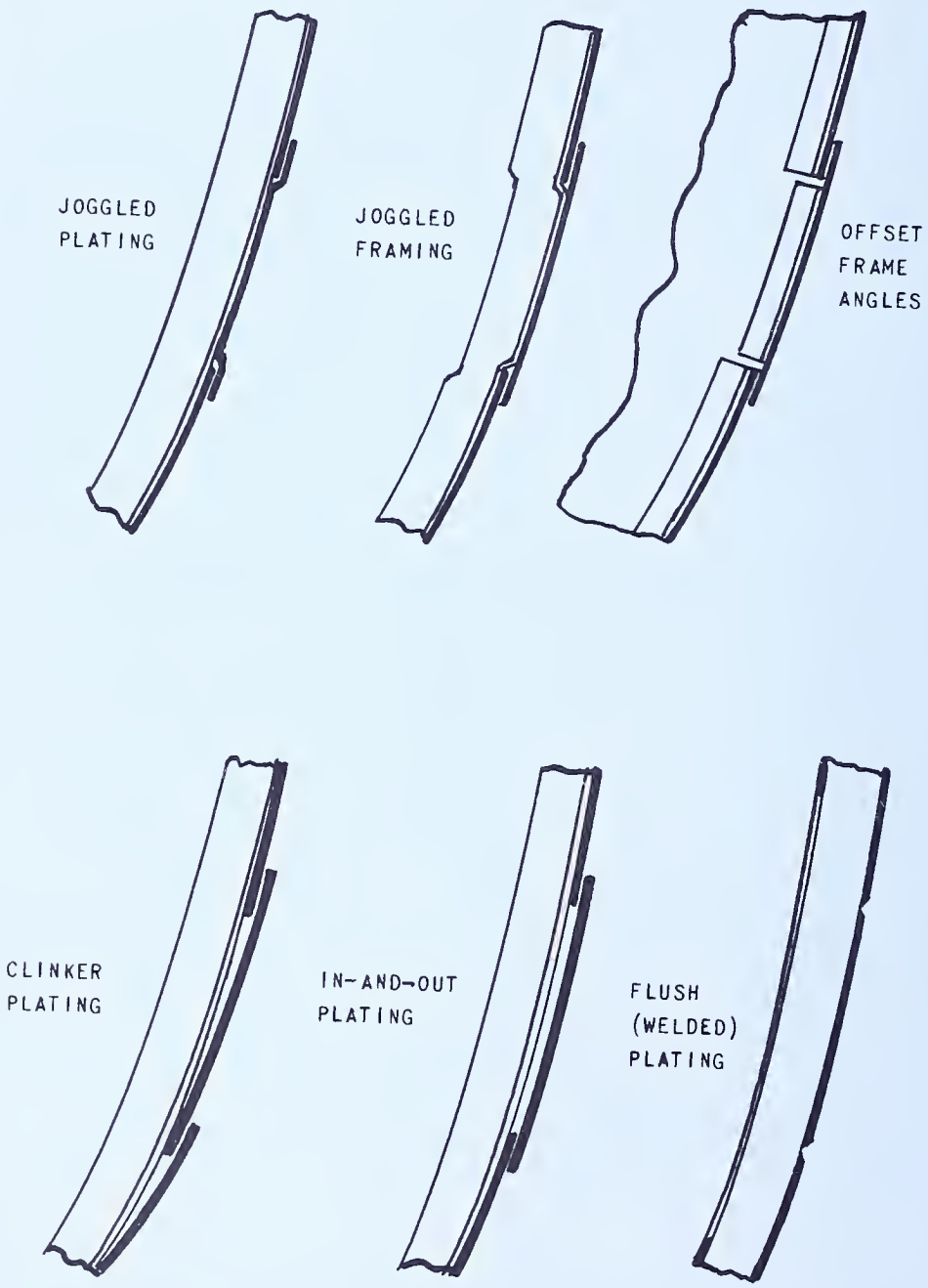


Fig. 60 -- Arrangements of Shell Plating

tight or oiltight, because both sides of the frame are usually in the same compartment. However, if a tight bulkhead is fastened to a bulb angle frame, or if the liners for any other reason must stop the flow of water or oil from one side of the frame to another, they are extended to the edge of the plate and beyond the heel and toe of the frame, as at (B) in Fig. 61, so that they may be caulked, as shown in Fig. 62, (A) and (B).

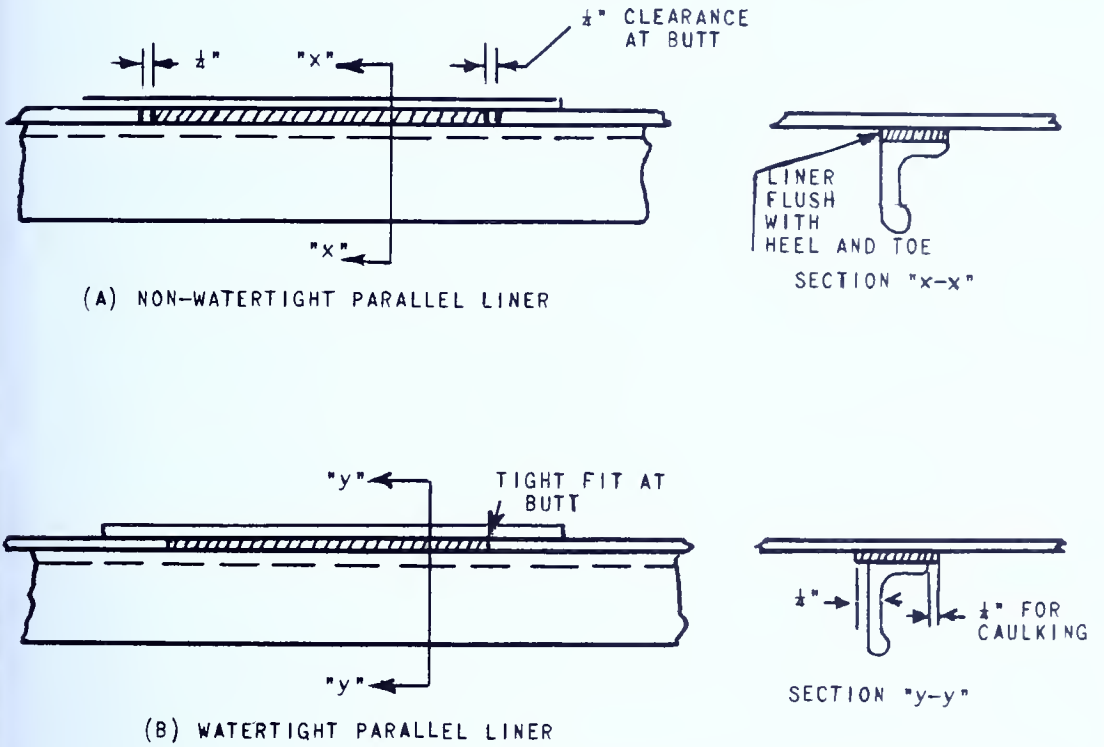


Fig. 61 -- Parallel Liners (Non-Watertight and Watertight

By caulking is meant the upsetting of the edge of the liner or the *angle* as shown in detail at (C), Fig. 62. This is done with a pneumatic hammer, using a tool shaped as shown in the sketch. The liner, by extending out a quarter of an inch beyond the heel and toe, forms a shelf to guide the tool. This shelf is known as the caulking edge on the liner. Caulking is never done until after the riveting is completed.

Table VIII-- Standard Flat Bar for Parallel Liners

Thickness	Widths
3/16"	2" 2½"
1/4"	2½" 3" 3½" 4" 5" 6"
3/8"	2½" 3" 3½" 4" 4½" 5" 6"
1/2"	2½" 3" 3½" 4" 4½" 5" 6"
5/8"	3" 3½" 4" 6"
3/4"	3" 3½" 4"
7/8"	4"
1"	3" 3½" 4" 6"
1¼"	3" 4"
1½"	3½"

Whenever possible, parallel liners are made of liner stock (flat bars), which is available in many thicknesses and widths and which can be sheared to any length. The standard thicknesses and

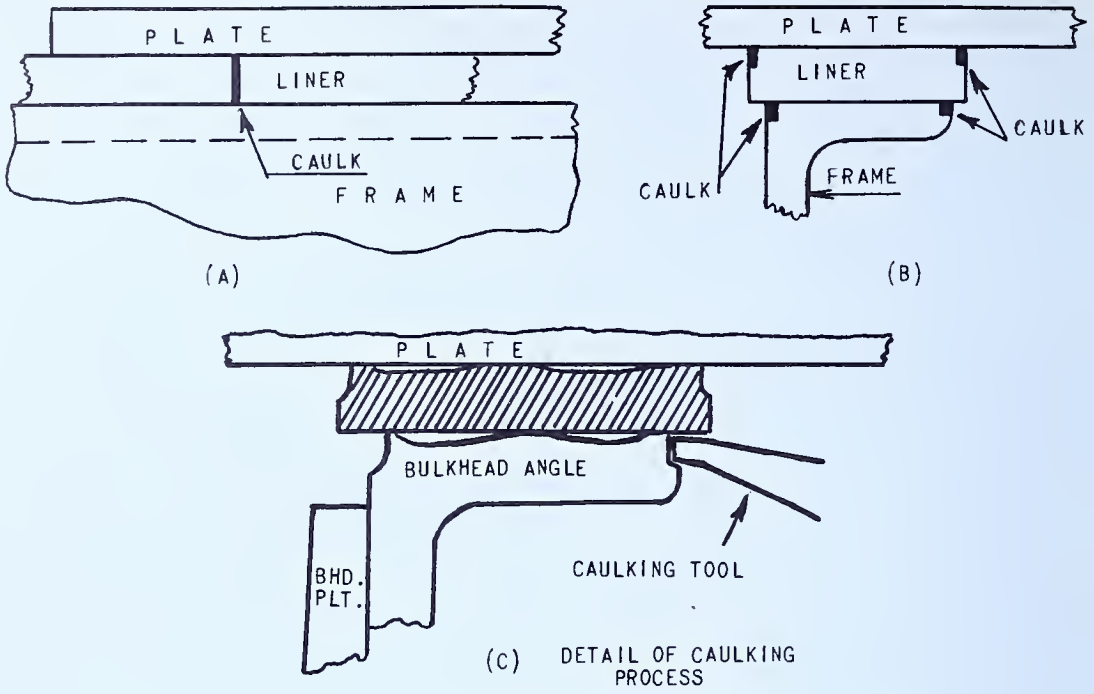


Fig. 62 -- Caulking of Watertight Liners

widths of flat bars, which are usually kept in stock, are given Table VIII.

Bars of intermediate thickness generally have to be ordered the job. In some instances, it is necessary to cut the liner f a plate, although this is troublesome, owing to distortion cau by the shears. The thickness of a liner must be within 1/16" the thickness of the plate against which it butts. At (B) in F 59, if the "E" and "G" plates both were 9/16" thick, either 1 or 5/8" would be satisfactory liner thickness. If "E" were 9/ and "G" were 11/16" thick, a 5/8" liner would be used.

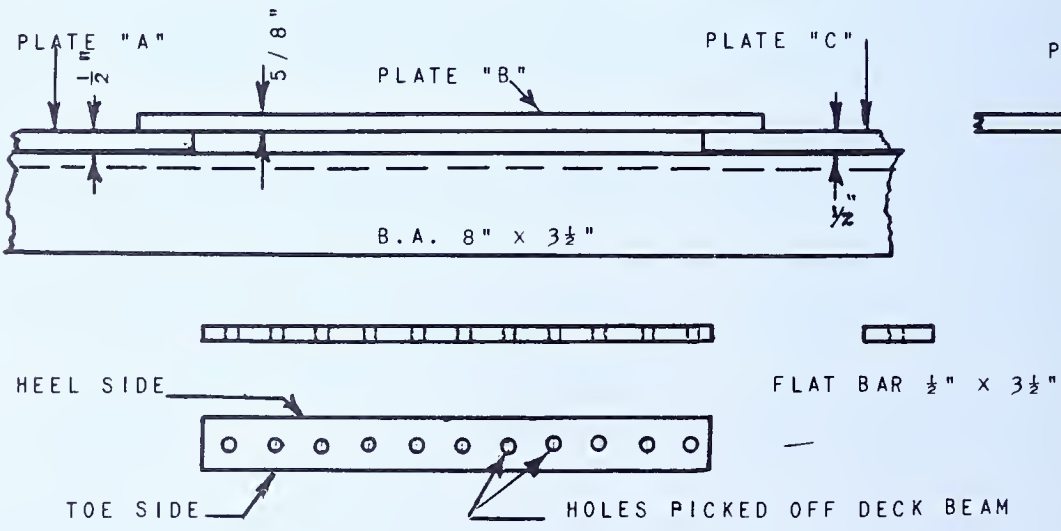


Fig. 63 -- Non-Watertight Liner for Deck Beam

How to Lift and Install a Parallel Liner

A parallel non-watertight liner is to be made for a deck beam, as shown in Fig. 63.

PROCEDURE:

1. Determine proper thickness of flat bar (stock) to be used.
   The two plates at the ends of the liner are each 1/2" thick, so the liner itself must be made of flat bar 1/2" thick. The plate over the liner is 5/8" thick, but this has no effect on the liner.

2. Determine width of flat bar to be used.
   The flange of the deck beam is 3-1/2" wide. Since the liner must be the same width, a 3-1/2" x 1/2" flat bar is used.

3. Determine correct length of flat bar to be used.
   Measure the distance "xx" between plates "A" and "B". Since the normal clearance between the liner and plate at each end is 1/4", twice this amount, or 1/2", should be subtracted from distance "xx". This will give the correct length of liner. (Consult leader for proper clearance; clearances other than 1/4" may be specified.)

4. Cut a strawboard template to the length of the required liner and hold or fasten in place tight against the flange of the beam, as illustrated in Fig. 64.

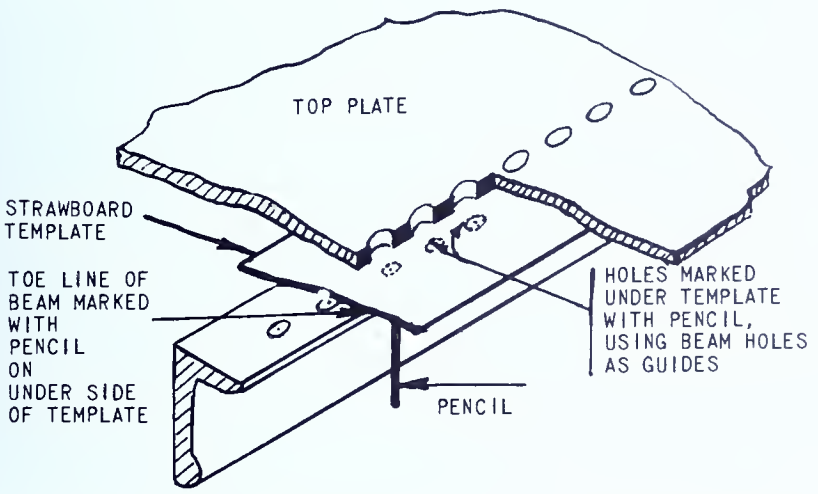

TOP PLATE
STRAWBOARD TEMPLATE
TOE LINE OF BEAM MARKED WITH PENCIL ON UNDER SIDE OF TEMPLATE
HOLES MARKED UNDER TEMPLATE WITH PENCIL, USING BEAM HOLES AS GUIDES
PENCIL

Fig. 64 -- Making Template for a Parallel Liner

The template may be held in place with spring clips, clamps, or wedges. (Templates are sometimes made of wood instead of strawboard.) The template usually is wider than the flange of the beam.

5. With a pencil, mark on the template, the toe line (or heel line) of the beam.

6. Mark the location of the holes for the liner on the unders of the template, using beam holes as a guide for the penc Although the circles thus made will be rough, the centers be spotted accurately for punching.

7. Remove the template and mark diameter of holes on templa These holes will be the same diameter as the correspond holes in the beam.

8. Mark on template, any identification necessary for install liner in proper position and location. (Hull number, fr number, port or starboard, outboard and inboard ends, heel toe, strake letter.) (See Fig. 65.)

9. Place template in position on the flat bar (liner stock) laying out and clamp securely.

10. Mark the length of the liner template on the flat bar sto for shearing.

11. Mark the hole locations on the liner stock, through the t plate, using a center punch.

12. Remove template and mark diameter of required holes on ste using a soapstone or paint.

13. Place all necessary identification marks on steel.

14. Have flat bar sheared to correct length (as marked in s "10". (The shears are not operated by the shipfitter.)

15. Have holes punched in the liner.
These holes must be the same diameter as the correspond holes in the beam from which the template was made.

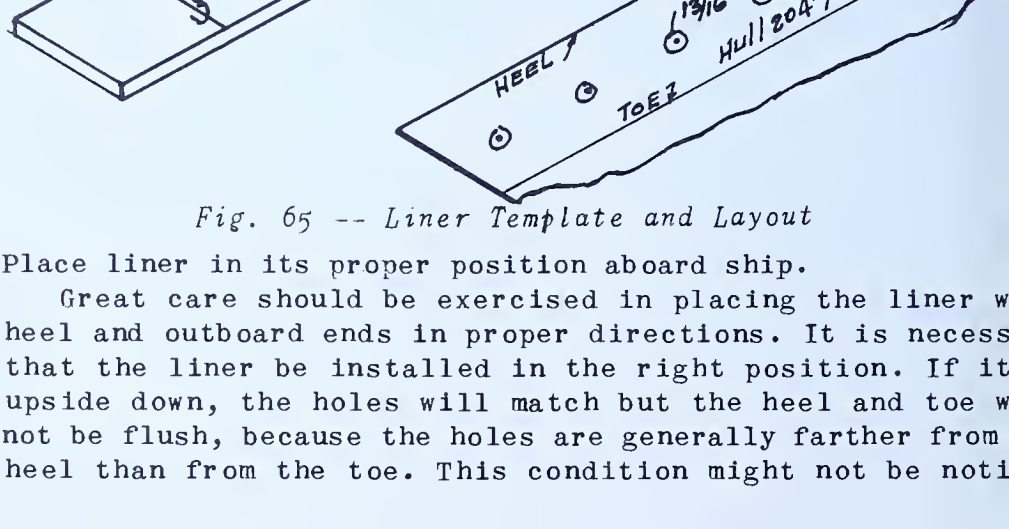


Fig. 65 -- Liner Template and Layout

16. Place liner in its proper position aboard ship.
Great care should be exercised in placing the liner w heel and outboard ends in proper directions. It is necess that the liner be installed in the right position. If it upside down, the holes will match but the heel and toe w not be flush, because the holes are generally farther from heel than from the toe. This condition might not be noti

until the deck is bolted, or even riveted, at which time it would be troublesome and expensive to correct.

7. Regulate the liner, using a drift pin, as shown in Fig. 66 (A). Regulating is the process of aligning the punched holes in

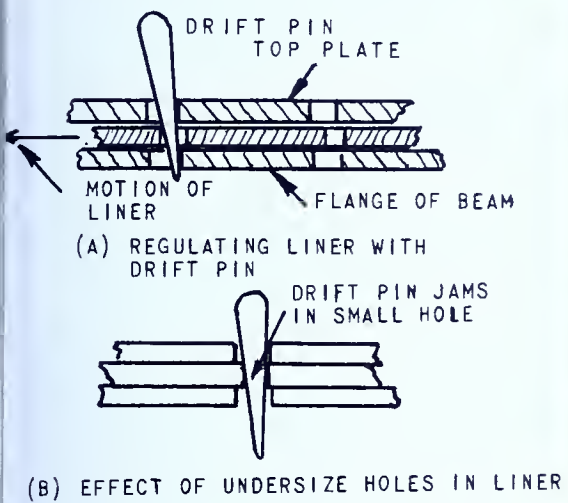

DRIFT PIN
TOP PLATE
MOTION OF LINER
FLANGE OF BEAM
(A) REGULATING LINER WITH DRIFT PIN
DRIFT PIN JAMS IN SMALL HOLE
(B) EFFECT OF UNDERSIZE HOLES IN LINER

Fig. 66 -- Drifting Liners into Place

Regulating With Bolts and Drift Pins

the liner with corresponding holes in the plate and beam, thus permitting the liner to be bolted in place. The pin is driven in with a maul, forcing the hole in the liner to slide over until the pin is tight. The pin is then knocked out and a bolt put in the hole. At least one bolt should be put in each liner. Figure 66 (B) shows the bad effect of punching undersized holes in the liner; the drift pin jams before the holes can be aligned.

Questions

1. What markings are required on a completed liner to insure that it will be correctly installed?
2. What is meant by a "watertight parallel liner"?
3. How may one determine the thickness of liner stock needed? How is the width of liner stock determined?
4. Does alignment of liner holes with beam holes prove that the liner is properly installed?
5. What is meant by "regulating a liner"?
6. Why does safety demand that a nut be put on the bolt which fastens a deck liner?
7. Why are liner holes punched on the same side as the holes in the adjacent members?

FITTING TAPERED LINERS

In Fig. 67 is shown a tapered liner for a deck beam under a plate lap. The butt or thick end of the liner must be the same thickness as the plate "A" in the sketch. The width of the liner must be the same as that of the deck beam flange if the liner is

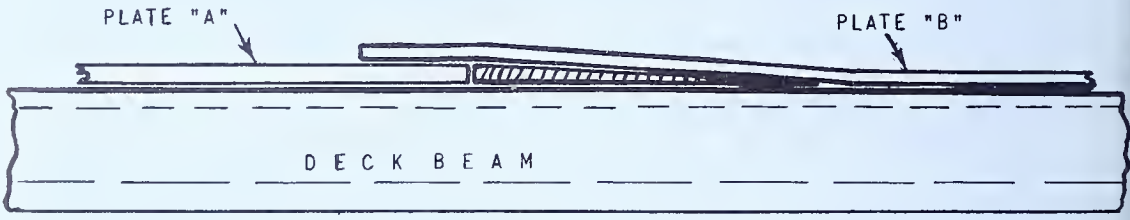


Fig. 67 -- Tapered Liner for a Deck Beam

non-watertight. and a half inch wider if the liner is watertight (1/4" each side for caulking). The length of the liner is taken from the following standard rule:

> *A tapered liner is 3" long for every 1/8" in thickness at the butt.*

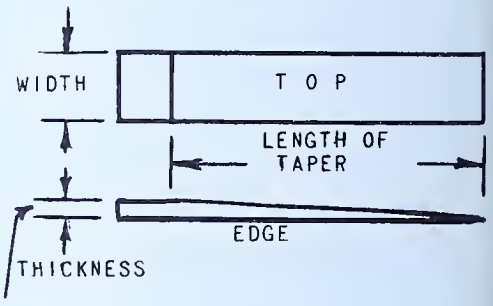


Fig. 68 -- Blank Liner

Blank liners are shaped as shown in Fig. 68. The butt is straight, or parallel, for a short distance and then starts to taper down to nothing at the opposite end. Standard taper is used. to suit the above rule. The straight part of the butt should always be sheared off when the liner is made, and is not included when measuring for the proper length of the liner.

Suppose that plate "A", in Fig. 67, is 3/8" thick. The liner must then be 3 times 3 inches, or 9 inches long. This standard taper is used when crimping plates or bars to cross a plate lap, and is tapered slowly or gradually enough to allow ordinary plates to be pulled to it without having previously been crimped. If it is found that a tapered liner of the proper length would end at a rivet hole as at (A) in Fig. 69, the liner should be lengthened or shortened an inch and a half as at (B) to keep the sharp end well away from the rivet. It is better to lengthen the liner than to shorten it.

How to Lift a Tapered Liner

PROCEDURE:

1. Determine proper butt thickness of required liner.
   This measurement will be the same as the thickness of the plate against which the liner butts.

2. Determine width of required liner.
   This measurement will be the same as the beam flange width if non-watertight. If watertight, 1/2" is added to the width (1/4" on each side) for caulking edges.
3. Determine correct length of tapered liner.
   The liner must be 3" long for each 1/8" of butt thickness.
4. Cut a strawboard template to the length of the required liner. Hold or fasten in place tight against the flange of the beam.
5. With a pencil, mark the heel line (or toe line) of the beam on the template.
6. Mark the location of the holes for the liner on the underside of the template, using the beam holes as guides for the pencil.
7. Remove template and mark diameter of holes on the template.
8. Mark on template any identification necessary for installing liner in proper position and location.
9. Choose from stock a blank tapered liner of sufficient width and correct butt thickness.
   Liner stock of various butt thicknesses and correct length of taper for each butt thickness is prepared in advance by the blacksmith shop.
10. Place the template on the liner and transfer markings to steel by punching through template. While this is being done, the template is held tight against the liner by a specially constructed pneumatic press on the table in the liner shed.
11. Remove template and mark diameter of required holes on steel, using soapstone or paint. Add additional markings necessary to secure the correct installation of the liner.
12. Have liner sheared to correct dimensions.
13. Have holes punched in liner.
   After the liner has been punched and sheared, and *before it is taken from the liner shed* to the ship, it must be care-

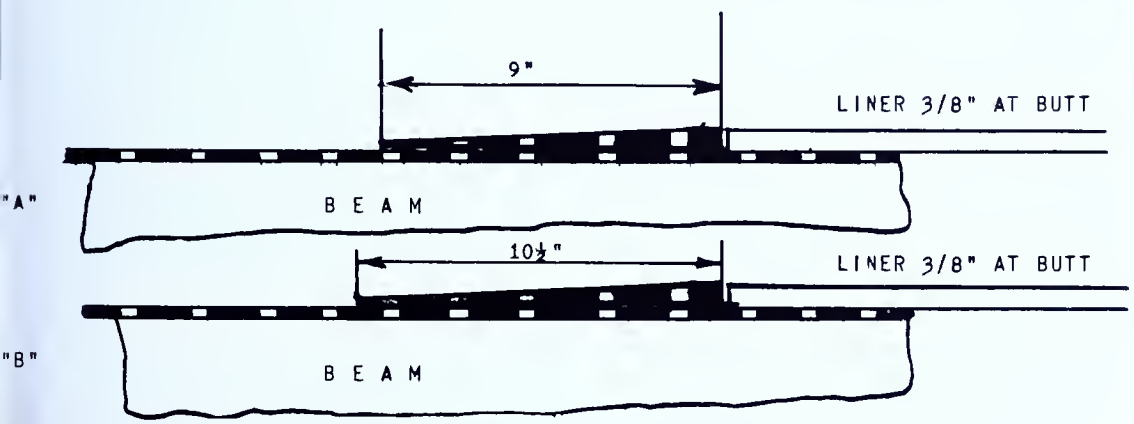


Fig. 69 -- Lengthening Liner to Clear Rivet Hole

fully inspected to make sure that there are no burrs of steel left on the edges. Any burrs found should be knocked off or flattened out with a hammer, as otherwise they might get between the liner and the plate and prevent the steel from being pulled up tight.

14. Place liner in its proper position on ship.

15. Regulate and bolt liner in place.

Tapered liners for other parts of the ship can be made in the same fashion. It is often possible to make a liner by picking up only the spacing of the holes on the edge of a template or batten without marking the lines on the template for the heel and toe. Then several liners can be lifted on one template by using colored pencils. This is especially useful where several liners must be made with the same width and gauge of holes. (Gauge is the distance from heel of bar to center of hole.) The gauge can be measured on the beam or frame. If gauges of the holes in the beam vary slightly, owing to inaccuracy in punching, several of them should be measured and the average used on the liner.

Questions

1. Why is a standard liner taper used?
2. Why are liners unnecessary in welded construction?
3. Where are tapered liners required?
4. What is the standard length of a tapered liner which will butt against 7/16" plate?
5. Why must burrs be removed from a liner before it is installed?
6. How are hole locations transferred from template to liner?

FITTING SPECIAL LINERS

"Special" liners are those which have other than standard taper, or which taper in two directions, owing to special conditions. In Fig. 70 is sketched a plate lap under a shell longitudinal. The plate "B" is scarfed, or cut away, at the lap for the longitudinal to pass. Both plates have their lapped edges crimped as shown. The scarfed plate is not cut down to a feather edge, but has a thickness "h" at the edge as shown. This will be the thickness of the butt of the liner, as shown in the plan view (B) at "dg".

Shell longitudinals are very rigid, as a rule, and the plate "C" is often very hard to pull up tight, particularly at the bilges, where the plate would be curved (rolled) transversely. The steel here would be hard to pull together with bolts, requiring that the heel edge of the liner "de" be longer than required by the rule of standard taper. The toe of the channel would bend down more easily than the heel (See section "A"-"A"); thus the toe edge of the liner "fg" would be shorter than the heel edge. The edge of zero thickness would then be "ef".

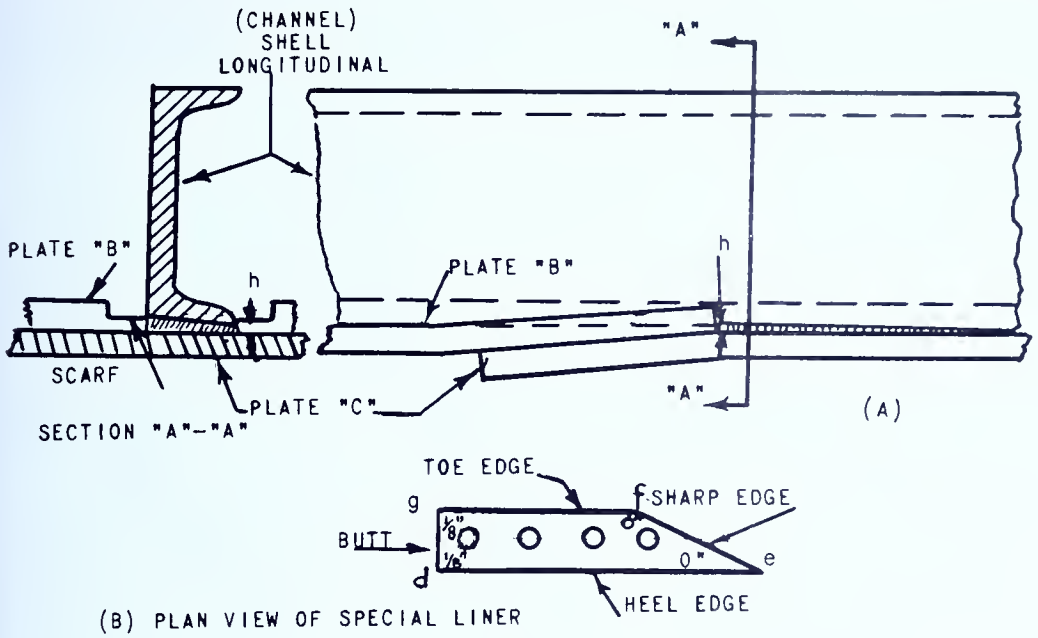


Fig. 70 -- Special Liner

How to Make a Special Liner

PROCEDURE:

1. See that adjacent members are tightly bolted.
2. Make a strawboard template of the same outline as the required liner.
3. Mark on template the corner thicknesses as illustrated at "d", "e", "f", and "g", in Fig. 70 (B).
4. Take the template to a blacksmith who will select stock and make a blank liner of the correct shape.
5. Apply the template to the blank liner and transfer marks to steel as explained in previous sheets.
6. Have liner sheared and punched.
7. Install, regulate, and bolt liner. (Refer to procedure sheet, "Lifting and Installing a Parallel Liner," if this step is not clearly understood.)

Use of Liners for Fairing

Another use of a special liner is in fairing shell plating at a frame which for some reason has the wrong curvature. It would be impractical to remove the frame or to fair it in place; therefore, the situation is remedied with a liner as shown in Fig. 71 (A).

The shell plate is pushed out from the frame until the curve appears smooth and fair from the outside of the ship. A liner of varying thickness is then made to fit the space between the frame and the plate. This liner is hammered out by a blacksmith, using a

shipfitter's template as a guide. If the bump in the frame is in way of two plates as in Fig. 71 (B), the shell is wedged out, as before mentioned, until it is fair, and two special liners are used. The liner for the inside plate is tapered to zero thickness.

Questions

1. What is a "special" liner?
2. What is meant by "fairing"?
3. How is the thickness of a special liner determined?

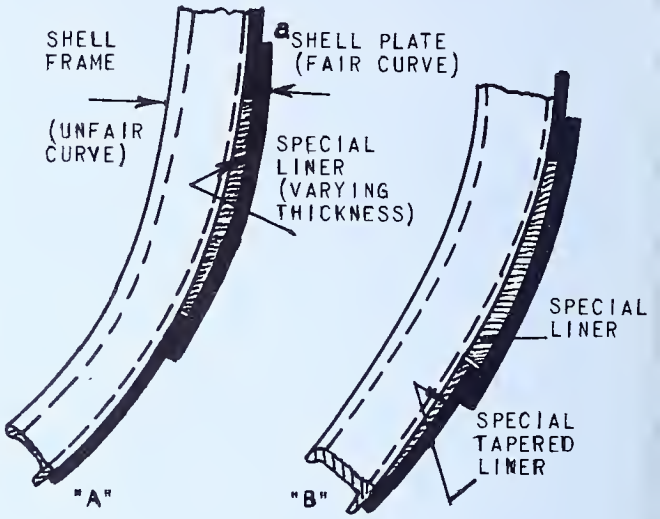


Fig. 71 -- Liners Used in Fairing

FITTING ROLLED LINERS

In making rolled liners the neutral surface is the only part which will not be shortened or elongated. The location of holes on the inside or outside face of the liner will change. Allowance must be made for this condition when making the template, as in Fig. 73.

As illustrated, small spacers are used (wood or otherwise) to hold the thin wooden template in position. The neutral surface of the batten should be located so as to exactly coincide with the location of the neutral surface of the finished liner after installation. The holes can then be marked with a pencil as previously

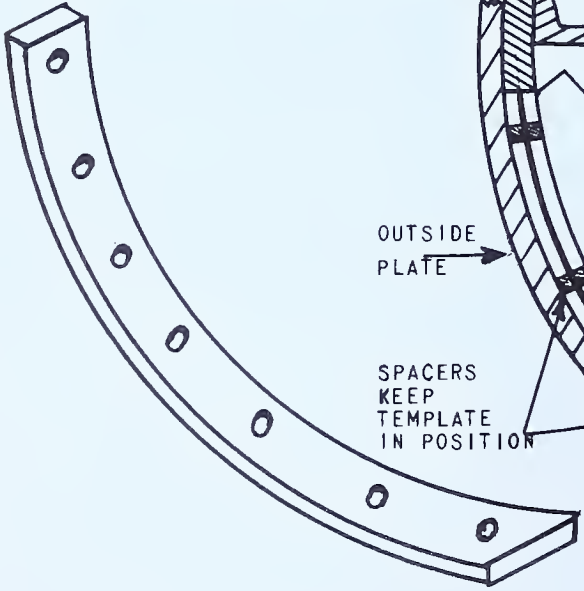


Fig. 72 -- Rolled Liner

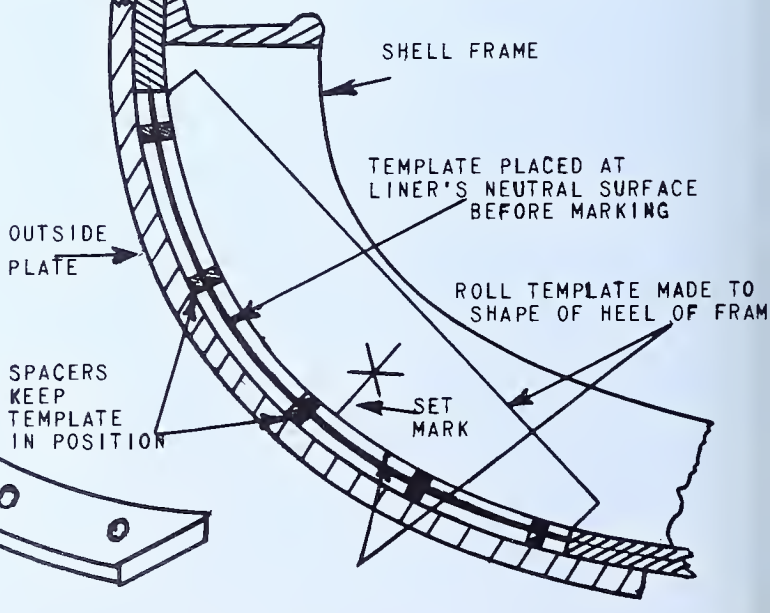

SHELL FRAME
TEMPLATE PLACED AT LINER'S NEUTRAL SURFACE BEFORE MARKING
OUTSIDE PLATE
ROLL TEMPLATE MADE TO SHAPE OF HEEL OF FRAM
SPACERS KEEP TEMPLATE IN POSITION
SET MARK

Fig. 73 -- Template for Rolled Liner

indicated, and laid out on the steel for punching before the shaping process. The holes will have the correct spacing at the neutral surface. This spacing will not change when the liner is rolled.

To get the proper curvature in a rolled liner, a roll template is made (See Fig. 73). This usually is a piece of batten with one edge cut to the shape of the heel of the frame. The workman who rolls or otherwise bends the liner uses this roll template as a guide. A set mark (as shown in Fig. 73) is placed on the roll template in such a position as to line up with a similar mark on the liner template (and later on, the liner). This insures the correct curvature in the liner, and prevents the roll template from being used upside down or in reverse.

Questions

1. What is meant by the "neutral surface" of a "rolled liner"?
2. Why are spacers used in lifting a template for a rolled liner?
3. What is a "roll" template?
4. Why are set marks used?

FITTING BOWED LINERS

One of the most difficult liner jobs on a ship is the lifting of a liner which has shape in two directions. This type of liner is often found near the ends of the ship between the shell frames and the outside strakes of shell plating. Fig. 74 (A) shows a view of two liners on frames at the forward end of a ship. The edges of each liner *in this view* appear straight, because all frame lines are straight in the side elevation. That is, the edge "ef" and the edge "gh" *appear straight in this view.*

At (B) is shown the section "xx" looking downward. Here it is seen that the sides of the ship are curving sharply inward as they go forward, and that the frames each have an open bevel.

At (C) is a view "Y"-"Y" looking directly aft at the two liners, (with the plates cut away). Here can be seen the curvature of the frames transversely. The combined effect of this frame curvature and the fact that frame #14 is farther inboard (in other words, smaller) than frame #15 will give the shell, in this neighborhood, almost a conical surface.

The liner when expanded, or flattened out, will appear bowed as shown at (D) in Fig. 74. This will be the approximate shape of the template used in laying out the holes.

To more easily understand the reason for this bow, suppose that the surface of the cone in (J) Fig. 74 is covered with paper strips of equal width, such as "l", "m", "n", etc. Because of the taper, the edge of each strip which is nearer the point of the cone, is shorter than the other edge. When the paper is taken from the cone and flattened out (as at "m") the strips will each be

bowed as shown. A little experimenting with strips of pape wrapped around a cone-shaped object will make this effect clear

Lifting a Bowed Liner

PROCEDURE:

1. Secure a piece of strawboard or batten wide enough, when i place and ready for marking, to extend on both sides of liner

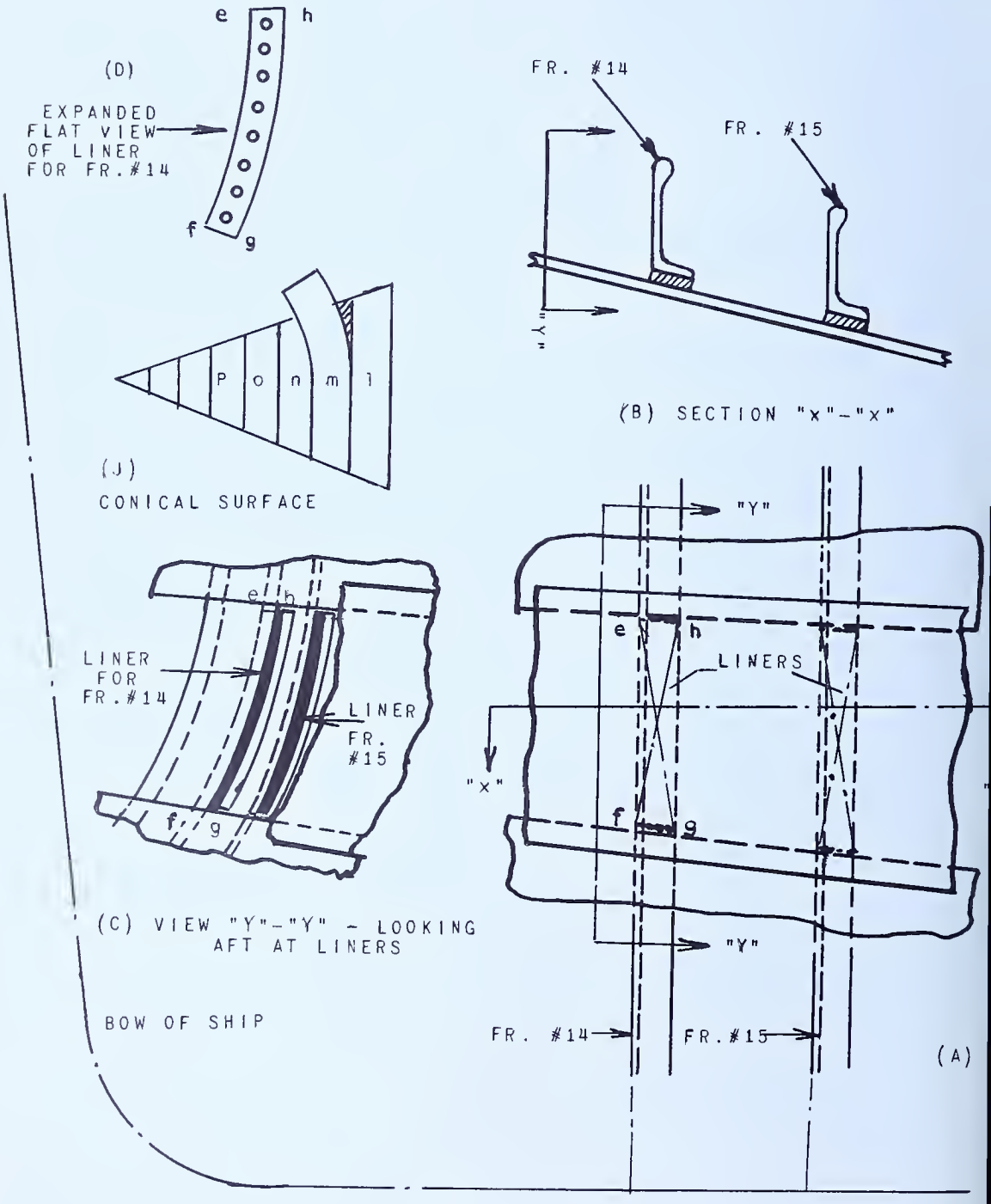


Fig. 74 -- Liners With "Bow", or Edge Shape

2. With spacers, set the batten to the center, or neutral surface of the liner, as explained for ordinary rolled liners.

3. Mark on the batten with a pencil the heel line, toe line, and location of holes in the frame.

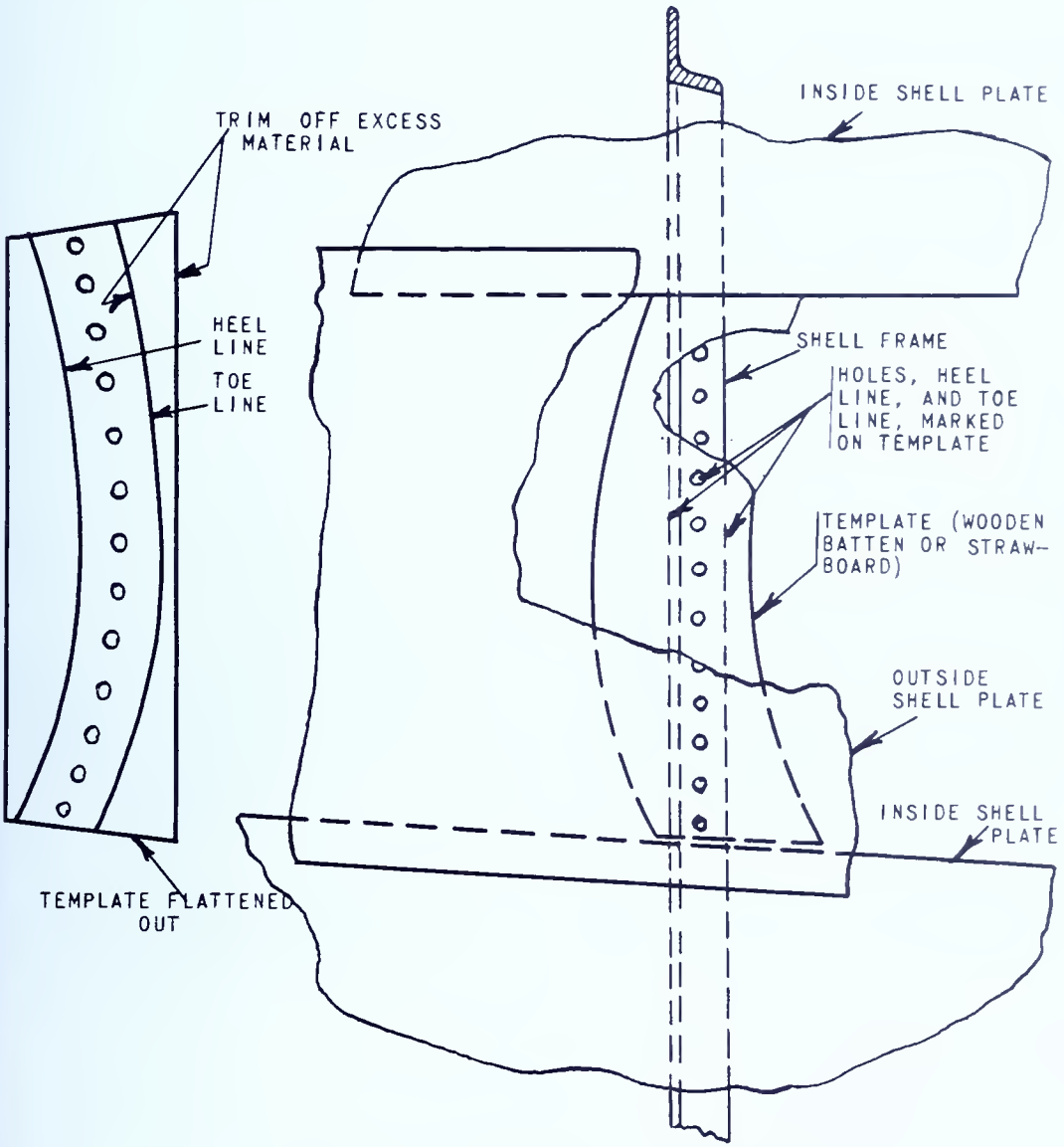


Fig. 75 -- Template for Bowed Liner

4. Make a roll set of wood or strawboard (as explained under "rolled liners").

5. Before removing templates apply set marks on liner template and roll set.

6. Remove the liner template and trim off excess material outside the heel and toe lines.

   The outline of this template after trimming and flattening is the shape which the liner must take before the liner is punched or rolled. This bow is called "edge shape".

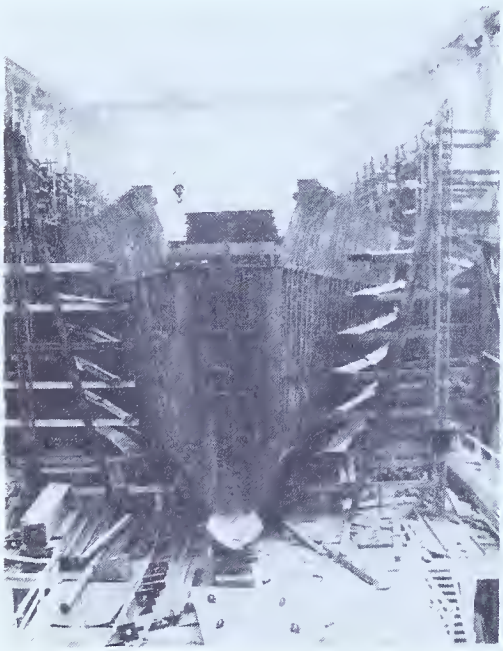
7. Secure flat bar stock of correct thickness and with a width equal to that of the frame flange.

8. Have the "edge shape", or bow, put into the bar, using template as a guide. This operation generally is performed at the cold press.

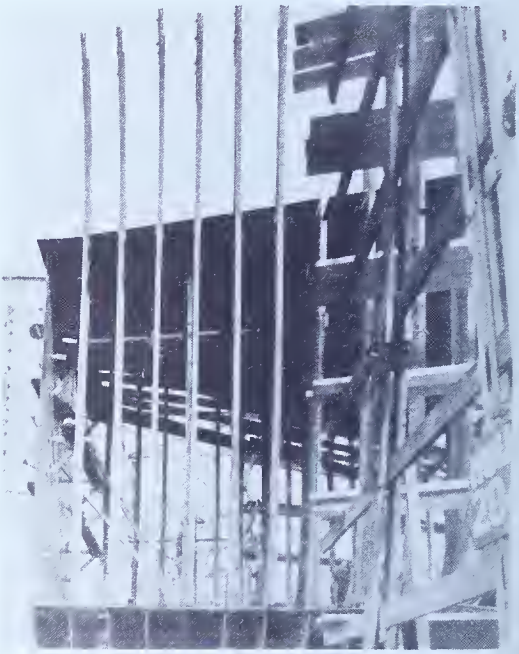
9. Lay out the holes and have the liner punched.
   After punching, the edge shape should again be checked with the template.

10. Have the liner rolled, using the roll set as a guide. Be certain that set marks match when applying roll set to liner.

11. Install liner, regulate, and bolt.



View Showing Shape of Frames at Forward Part of Ship



Side Elevation Showing Shell Frames (Riveted Construction)

Questions

1. Why do some liners require edge shape?
2. Why is a wide batten needed in lifting a bowed liner?

PRECAUTIONS FOR INSTALLING LINERS

Figure 76 illustrates several points which should be noted when installing liners on the ship. At (A) is illustrated the way of driving a liner into a space which, for some reason, cannot be wedged open wide enough for easy entrance. The force of the hammer is taken up by a piece of scrap steel and transferred smoothly to the liner, which is driven in without upsetting its

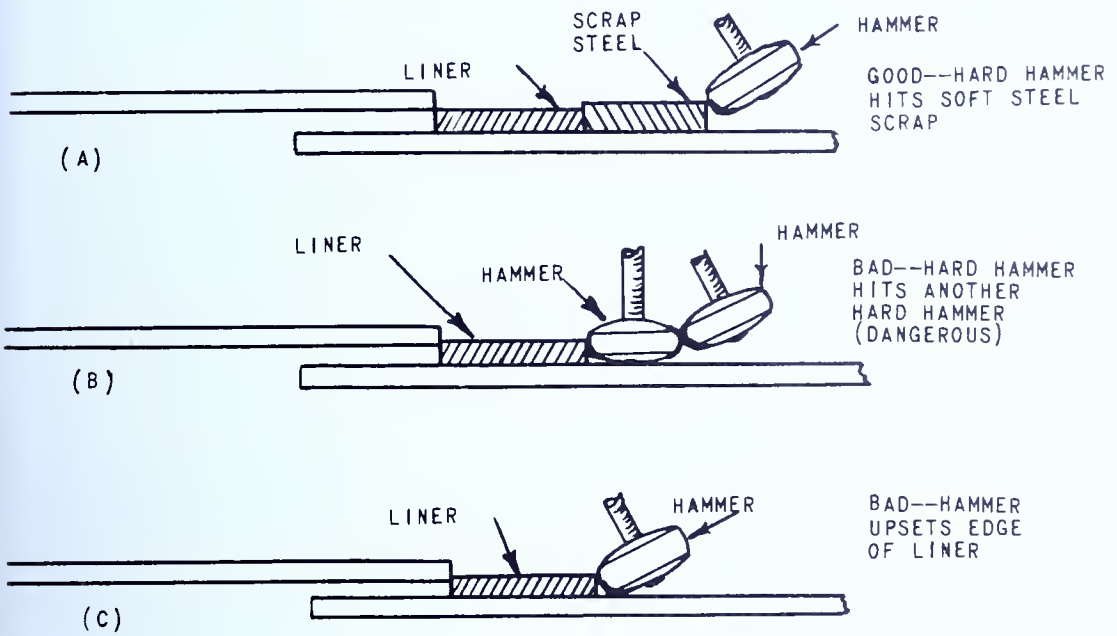


Fig. 76 -- Precautions When Installing Liners on Ship

edge. The method shown at (B) is dangerous. When one hard hammer is hit by another, sparks or chips are often thrown off, and might very easily injure an eye. The method illustrated at (C) is bad for the reason previously mentioned; that is, the edge of the liner will be upset and distorted by the hammer blows.

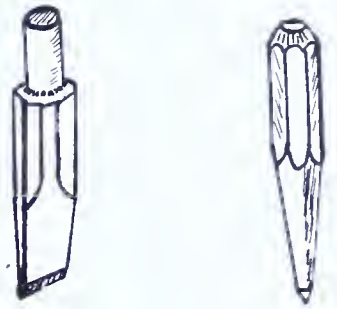


Fig. 77 -- Air Gun Chisel and Center Punch

Chisels for an air gun should never be used with a hand hammer; such chisels are hardened at the top and often throw sparks or chips.

Figure 77 shows an air gun chisel and also illustrates how a center punch should be ground to prevent chips being knocked off by the hammer.

SHORT ANGLE BARS AND CLIPS

Angle bars are widely used in riveted work for fastening together two plates approximately at right angles. This use in welded jobs is practically eliminated, except where one of the plates is to be portable (fastened with bolts). Angle bars are used, however, in the construction of foundations for machinery and other equipment and also as stiffeners for decks, bulkheads, etc. A short piece of angle is generally referred to as a clip.

The small angle clips so common in riveted work very often must be trimmed or fitted on the job. Many cases arise where a new clip

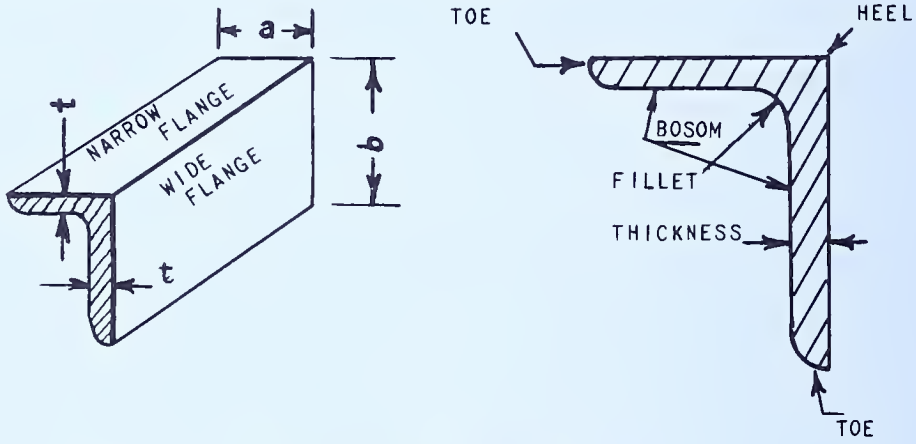


Fig. 78 -- Unequal Angle

must be "lifted" from the ship, dimensions being taken from the adjacent steel which is already in place.

The two legs, or sides of an angle bar are called flanges. The widths of these flanges, together with the thickness of the steel, give a measure of the size of the angle, and also of its strength. The angle bar shown in Fig. 78 would be known as an unequal angle, since the two flanges have different widths.

The width "a" of the narrow flange is taken from the heel to the toe as shown. The width "b" of the wide flange is also taken from heel to toe. The thicknesses "t" of the two flanges are equal for standard angles.

A 6" x 3½" x 3/8" angle would be one whose flange width "a" is 3-1/2", flange width "b" is 6", and thickness "t" is 3/8". The toes of an angle, except in special cases, are rounded off as shown, and the bosom is built up, or filleted, to increase the strength.

FINDING THICKNESS OF FLANGE

On hull blue prints, the thickness of an angle bar usually is not given directly, but the weight per foot is specified. To find the thickness of the flange the following formula is used:

$$T = \frac{5W}{A + B}$$ (Answer in sixteenths)

W is the weight in pounds per linear foot of the angle. A and B are the widths of the two flanges in inches. The answer "T" will be the thickness of the angle flange in 16ths of an inch. Example: A drawing calls for a 6" x 3-1/2" x 11.7# angle.

Then, W = 11.7# (per foot)
A = 3½"
B = 6"
Using the formula,

$$T = \frac{5W}{A+B} = \frac{5 \times 11.7}{3.5 + 6} = \frac{58.5}{9.5}$$

$$\text{Thickness} = \frac{6.15}{16} \text{ or } \frac{6}{16} = 3/8$$

Thickness = 3/8"

$$95.\overline{)585.00} \quad 6.15$$
570
150
95
550
475
75

It is seen that "T" comes out slightly greater than 6, but as we need only measure to the nearest sixteenth, we can neglect the .15 and say that the thickness is 6/16" or 3/8".

Landings and Gauges for Angle Bars

When rivet holes are made in the flanges of an angle, they are carefully kept a certain distance from the heel, depending on the size of the angle and the diameter of the rivets. This distance from the heel of the bar to the center of the hole, is called the "gauge" of the hole.

Measurements for angles are always taken from the heel line,

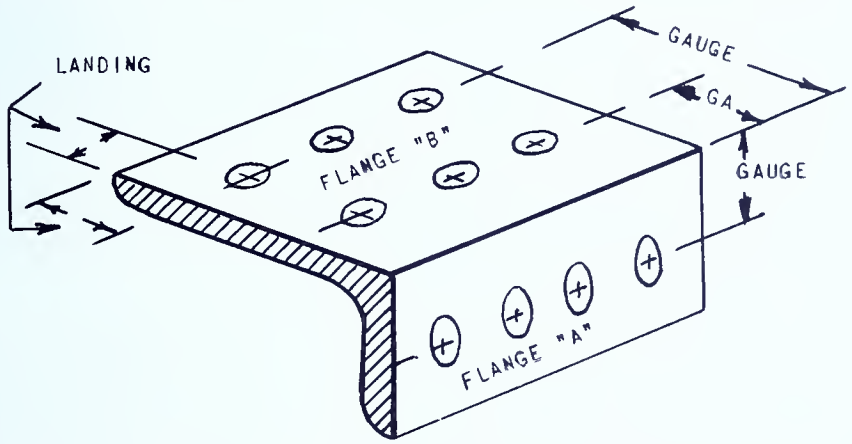


Fig. 79 -- Gauge and Landing of Holes in Angle Bars

because the toe is rounded off and sometimes irregular. It is necessary that all rivet holes have a "landing" of *at least* 1-1/2 times the rivet diameter. That is, the center of the hole must be 1-1/2 diameters from the *edge* of the flange (either the toe or the

sheared end). This is a rule followed in the mold loft, shop, an yard in general. The "landing" rule also applies to plate edge and bars other than angles. Table IX shows the correct gauge for angle bars of different sizes, tabulated for different diamete rivets.

Table IX -- Standard Gauges for Angles

Dia. of Rivets	FLANGE OF ANGLE							
	2"	2-1/4"	2-1/2"	3"	3-1 2"	4"	5	6
1/2"	1-1/16"	1-1/4"	1-3/8"					
5/8"			1-3/8"	1-3/4"	2"		2"+1-5/8"	
3/4"			1-1/4	1-5/8"	2"	2½"	2"+1-5/8"	2¼"+2
7/8"				1-1/2"	1-7/8"	2¼"	1-7/8"+1½"	2¼"+2
1"					1-3/4"	2-1/8"	3"	2"+2
1-1/8"						2"	2½"	2"+

This table has been compiled so that the landing (from the toe will be sufficiently large, and so that the head of the rivet can not foul the other flange of the angle.

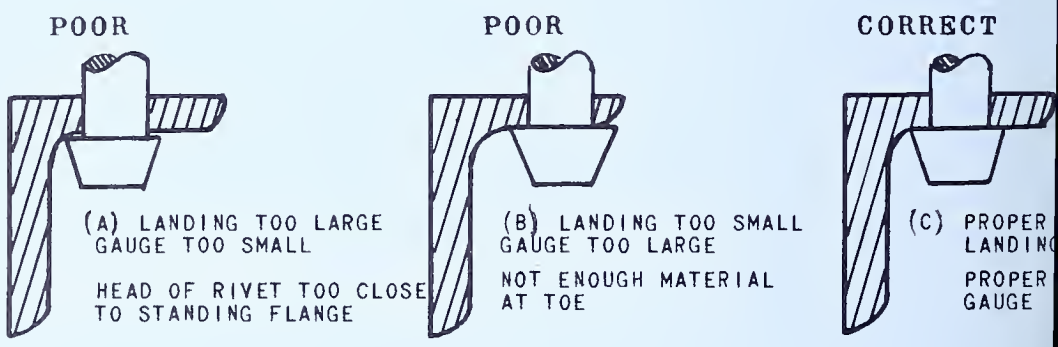


Fig. 80 -- Effect of Varying Landing and Gauge

Figure 80 illustrates the bad effects of using improper gauge for rivet holes. These conditions must be avoided when choosin the size of angle bar for a lifted clip.

Making Angles Watertight or Oiltight

Riveted angles for watertight or oiltight work have the toe planed for caulking. The curved or irregular portion at the to of the flange is removed, so that a section through the ba appears as in Fig. 81 (A). After the caulking process, a sectio through the bar appears as in (B).

RIVET SPACING

Another consideration when making a clip oiltight or water tight is the spacing of the rivets. The closer together the rive

are spaced, the more firmly and tightly the bar is pressed against the plate when it is caulked, and the less chance there is for the caulked edge to open up between rivets. Experience has shown that oil will sometimes pass where water could not go. Rivets for oil-tight work are therefore spaced closer than those for watertight work. The rivet spacing (or pitch) for any member is specified on the blue print for the section of the hull in question. If it is necessary to determine the rivet spacing before making the clip (that is, if the plate does not already have the holes punched in it) the drawing or the shipfitter leader should always be consulted.

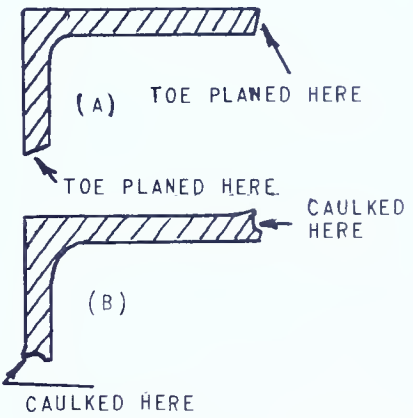
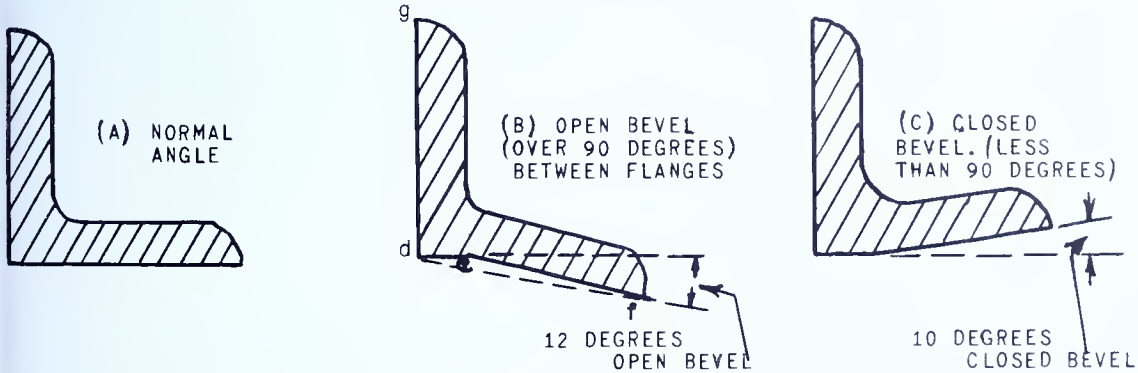


Fig. 81--Caulking Toes of Angle Bar

A great many of the clips and other small angle members must have their flanges either spread out or pulled together from their normal or perpendicular position. This is called beveling the angle.

Beveling and Shaping of Angles

Figure 82 illustrates a normal angle and also angles with open and closed bevels. (The beveling is done in the blacksmith shop.) Where possible the steel is placed so that the angle will have an *open* bevel, as at (B), rather than a closed bevel, as shown at (C). The purpose of this is to prevent the necessity of riveting in tight corners, where it would be difficult or perhaps im-


(A) NORMAL ANGLE
g
d
(B) OPEN BEVEL (OVER 90 DEGREES) BETWEEN FLANGES
12 DEGREES OPEN BEVEL
(C) CLOSED BEVEL. (LESS THAN 90 DEGREES)
10 DEGREES CLOSED BEVEL
Fig. 82 -- Normal and Beveled Angles

possible, to insert rivets and have them properly backed up or "held on" while they are being driven. (The member of the riveting gang who backs up the rivets is known as a "holder on". An open bevel gives him more room to work.) Note that the bend does not start at the heel, but at "e" in Fig. 82 (B). The flange "df" will therefore be bent at "e". When possible, work should be planned so that "dg" (the flat or best flange) will be against the continuous member (shell in Fig. 83) to insure tight rivets.

SHAPED ANGLES

Because of the curvature of the shell, and for other reasons angle clips must often be shaped or bent. Sometimes this curve is smooth and easy, and sometimes it is very sharp. In either case the work is done by an anglesmith, who is given templates made by the shipfitter to show the necessary shape.

In Fig. 84 is shown a curved angle bar. Furnaced (shaped) bars with both curvature and bevel are sometimes needed.

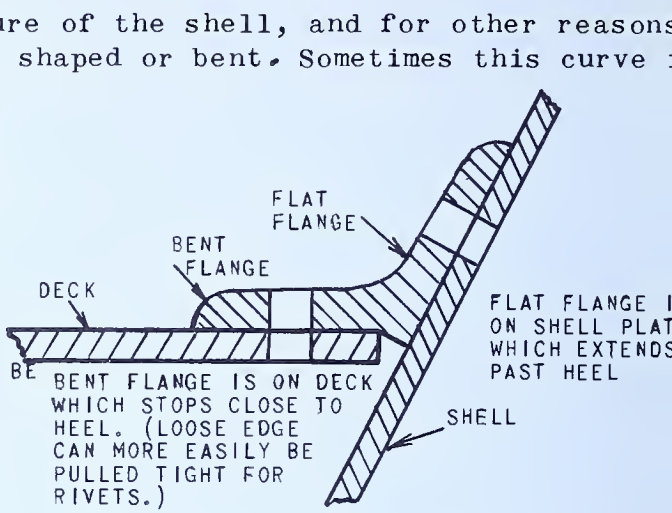


Fig. 83--Flat Flange Placed Against Continuous Plate

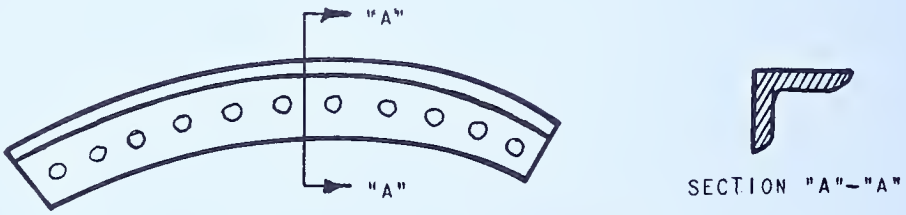


Fig. 84 A Shaped Angle

Questions

1. What is a "clip"?
2. How thick is a flange of a 3" x 3" x 4.9# angle?
3. Distinguish between the words "gauge" and "landing" as appli to angle bars.
4. What is the gauge for 7/8" rivets in the narrow flange of 6" x 3-1/2" x 11.7# angle?
5. How are angle clips made watertight?
6. What is the difference between oiltight and watertight riv spacings?
7. What is meant by a "closed" bevel? Why is an "open" bevel pr ferred?

LIFTING ANGLE CLIPS

When lifting the shape of angle clips from the hull structure, a template is made for each flange of the angle, with set marks on each to show the spot on the heel where the two templates are correctly aligned. For simple clips without curvature, a single template is sometimes made, with a fold, or crease, at the heel of the bar. Strawboard 1/8" thick is generally used for this purpose, allowance being made for template thickness.

In Fig. 85 is illustrated the marking of a folded template used in making a bottom clip of an intercostal plate in a longitudinal girder. This clip is required for stiffness and strength only, and need not be watertight.

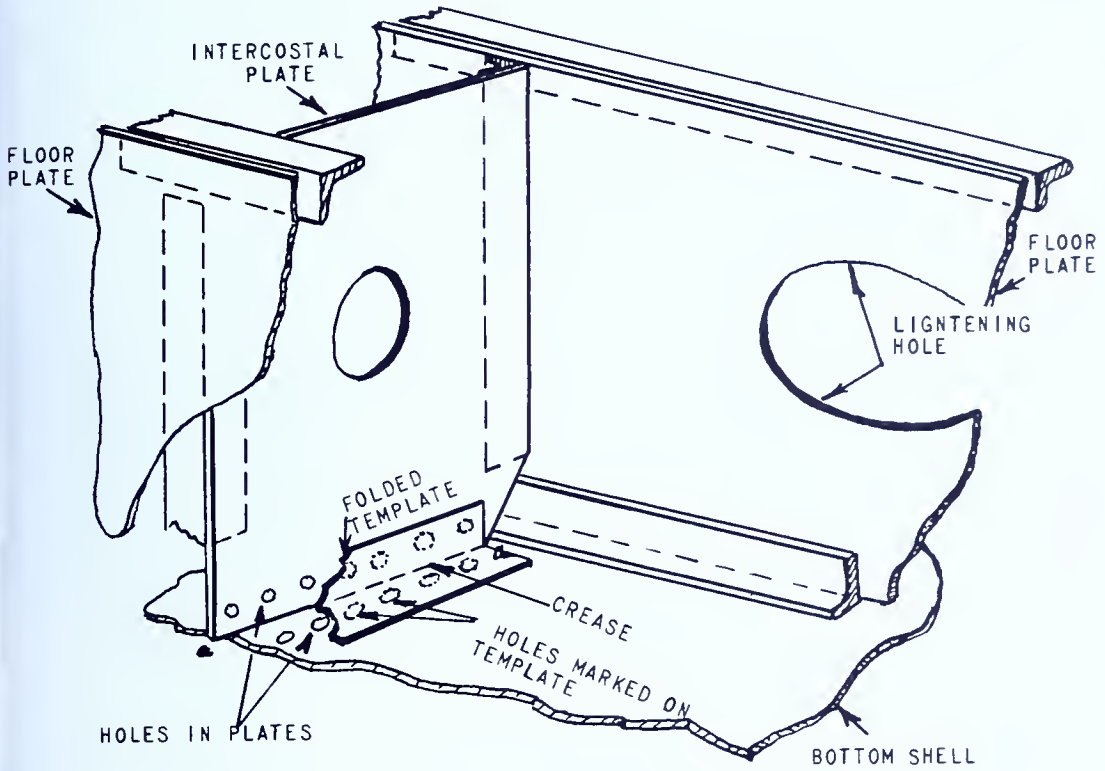


Fig. 85 -- Making a Template for an Angle Clip

How to Lift a Short Angle Clip

(As illustrated in Fig.85.)

PROCEDURE:

1. Remove all bolts or other gear from the holes which the clip will fit.

   Any obstructions would prevent the accurate lifting of the template as well as the installation of the completed clip.

2. Determine the dimensions of angle to be used.

Usually an adjacent clip in the same relative position wil be the proper size. A measurement of the holes which requir the largest gauge, or heel distance, will show whether such a angle will still have the minimum landing at the toe (which i 1-1/2 rivet diameters). If not, an angle with a slightly wide flange must be used. If there is any doubt about the thickness of the angle, the drawing should be consulted.

The length of the clip must be such as to give the prope landing to the last hole at each end of each flange. Sometime the corner of a flange must be snipped off to prevent foulin other members, but a landing of 1-1/2 diameters must always b maintained.

3. Secure a piece of strawboard of proper length and width

The width of the strawboard should be at least the com bined widths of the two flanges of the required angle.

4. Mark the heel line on the strawboard and score this line b cutting half-way through the strawboard with a knife.

5. Fold template and place with crease at location which will b occupied by heel of required clip (See "aa", Fig. 85).

The fold must be in such a direction as to *open* the cut rather than close it, so that the strawboard will not tea apart.

6. Cut the template to the outline of the required flanges an mark the holes through the plates with a pencil.

If access cannot be had to the opposite side of the plates proceed as follows:

Using a hammer, tap strawboard over each hole in the plate thus accurately imprinting the location of each hole on th template. By using a ball-peen hammer, holes can be cut throug the strawboard.

7. Mark on the template any identification necessary for th proper location and position of the clip.

Note: *If the bottom shell is not at right angles (perpendicu lar) to the intercostal plate, the lifted clip must be beveled Steps, 8, 9, 10, and 12 must be followed if bevel is required*

8. Using bevel square (adjustable bevel), pick up the require bevel as illustrated at (A) in Fig. 86.

"Picking up the bevel" is done by loosening the wing nut o the bevel square, adjusting the head and blade of the bevel t the required angle and then tightening the wing nut.

9. Place the adjusted bevel square against a straight edge of th template and lightly mark the bevel on the template (as illus trated in (B), Fig. 86).

10. Move bevel square so that the lifted bevel is closed abou 2 degrees, marking this line clearly. This is the require bevel for the clip.

The bevel marked on the template is closed about two degrees from the actual bevel picked up to make sure that the heel of the angle will be tight, as illustrated in Fig. 87.

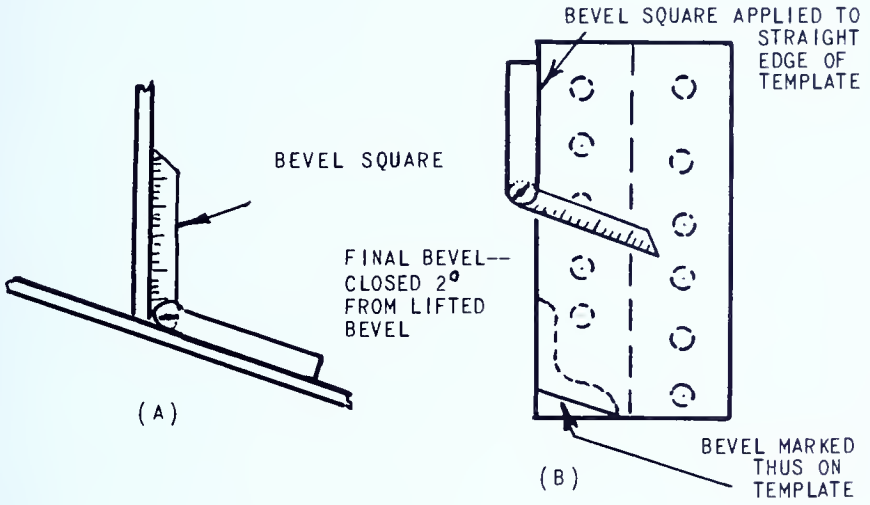

BEVEL SQUARE APPLIED TO STRAIGHT EDGE OF TEMPLATE
BEVEL SQUARE
FINAL BEVEL-- CLOSED 2° FROM LIFTED BEVEL
(A)
(B)
BEVEL MARKED THUS ON TEMPLATE

Fig. 86--Bevel Mark

11. Secure an angle of the proper "scantlings" and have it sheared to the required length. (Allow extra stock if shaping is required.)

    Note: Scantlings are the cross section dimensions of any rolled bar or shape. The term scantlings in the case of flat plate usually refers to thickness only.

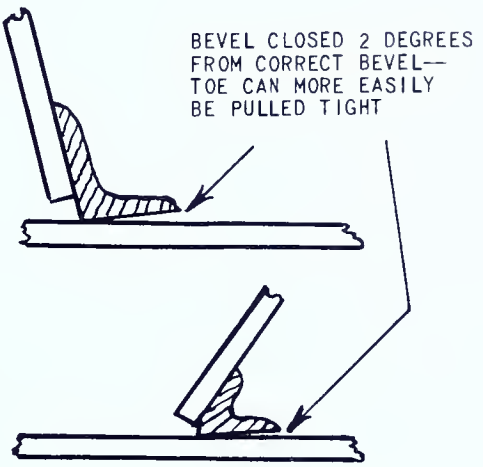


Fig 87—Bevel Closed Two Degrees

12. Take the template and sheared angle to the anglesmith and have the angle beveled.

    In Fig. 88 is shown a degree-board for angles (or other structural shapes) as used in the blacksmith shop. The anglesmith can take the bevel from the shipfitter's template with a bevel square, and place it on the degree-board to find exactly what angle is wanted. He can then select the proper bevel set to use.

13. Lay out clip for punching, and additional shearing if necessary. (Beveled angles must be burned; the shears would change the bevel.)

    Allowance must be made for the thickness of the template as shown in Fig. 89.

The strawboard is about 1/8" thick; therefore, the in side of the template, while being lifted, is 1/8" above an inside the spot which the heel of the clip will occupy, as a (A), in Fig. 89. When the template is applied to the angle fo laying out, the *inside* of the template is at the heel, an each mark is displaced *toward the heel* 1/8 of an inch.

It is necessary to center-punch the mark on the angle distance of 1/8" *further out from the heel*, as shown at (B) in Fig. 89. (If a thicker or thinner template is used, th distance the mark is moved is lengthened or shortened to suit.

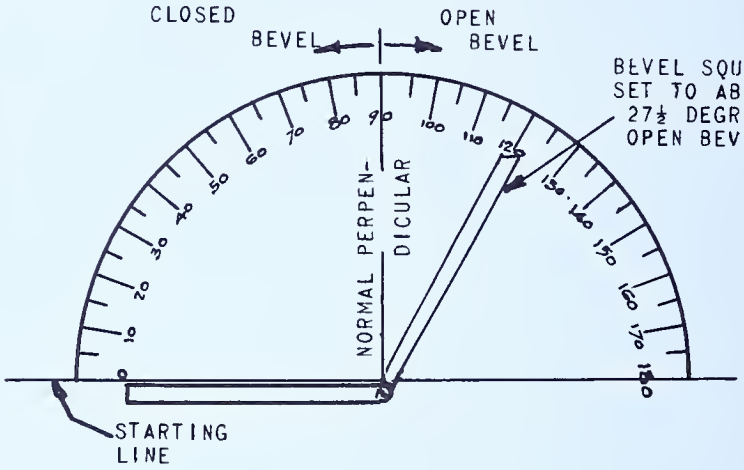


Fig. 88 Degree Board for Angles

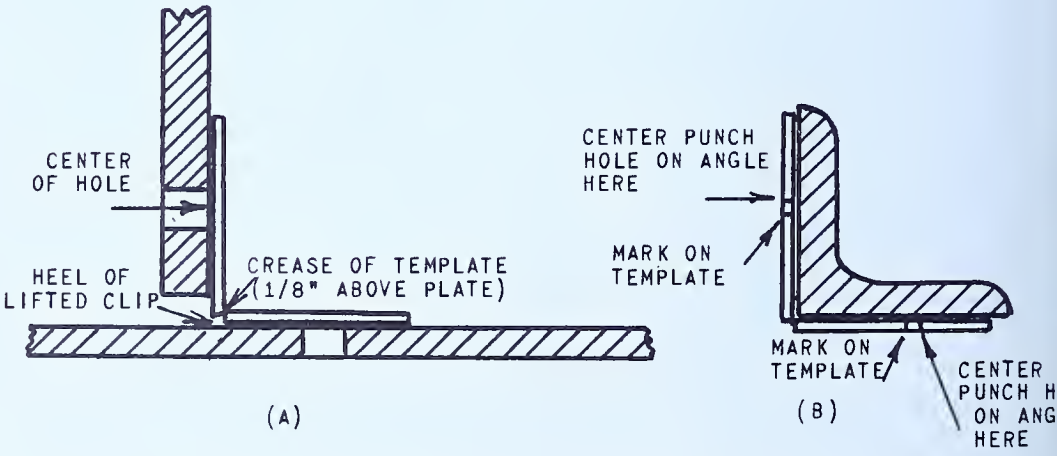


Fig. 89 -- Allowing for Template Thickness When Laying Out Angles

Questions

1. What is meant by "lifting" an angle clip?
2. Why must bolts be removed from holes which the clip must fit?

3. List identification marks necessary in properly locating and installing an angle clip.
4. When must angle clips be beveled?
5. When beveling a clip, what precaution is taken to insure that the heel of the installed clip will be tight?
6. How is allowance made for the thickness of a strawboard template in laying out a clip?

LIFTING CLIPS BY MEANS OF WOODEN BATTENS

FIRST METHOD

Clips may be lifted with wood battens rather than strawboard. One method is to use a batten for each flange with set marks for proper alignment. This method is illustrated in Fig. 90. (The mark "H" shows the *heel* location for laying out the clip.)

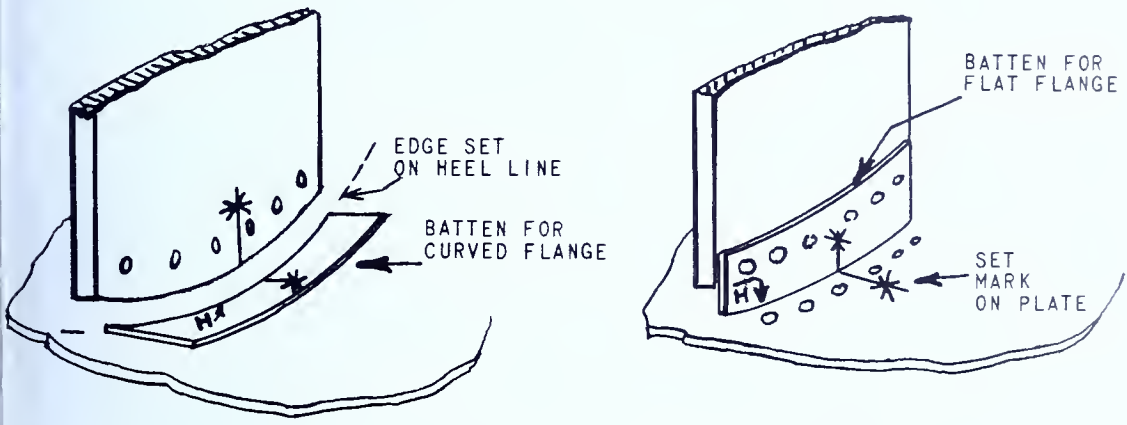


Fig. 90-- Lifting Clips With Two Battens

SECOND METHOD

Another method uses a single batten. The holes are laid out as usual for one flange and any necessary bevels marked on it. A set mark is then marked on the batten and on the steel. This mark is cut through the batten so that it may be seen on the opposite side of the wood, as shown at (B), in Fig. 91.

The batten is then turned down in place on the other plate so that the holes for the second flange can be laid out on the opposite side of the batten.

THIRD METHOD

The third method also uses a single batten. The first flange is marked as at (A), in Fig. 91. Without moving the batten, the holes from the lower plate are then squared over to the batten and spotted on the heel line, as shown at (A), in Fig. 92. If the gauge of the holes varies slightly, each individual gauge should be written on the batten at the correct spot, as shown at (B) in Fig. 92.

Pencil marks are made as at (B), Fig. 92, to show that thes spots are used for hole spacing, and a notch is cut at each spo so that the holes will not be lost if the pencil marks becom

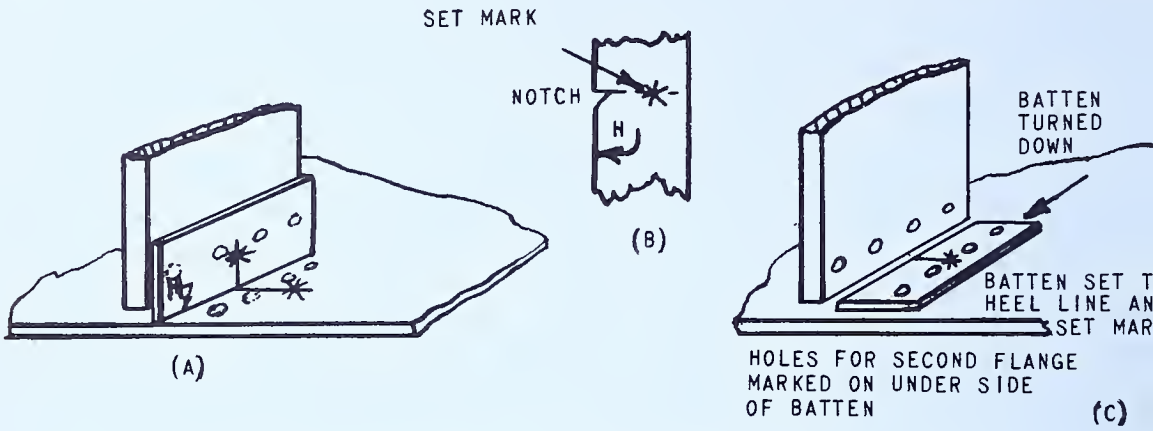


Fig. 91 -- Lifting a Clip With a Single Batten

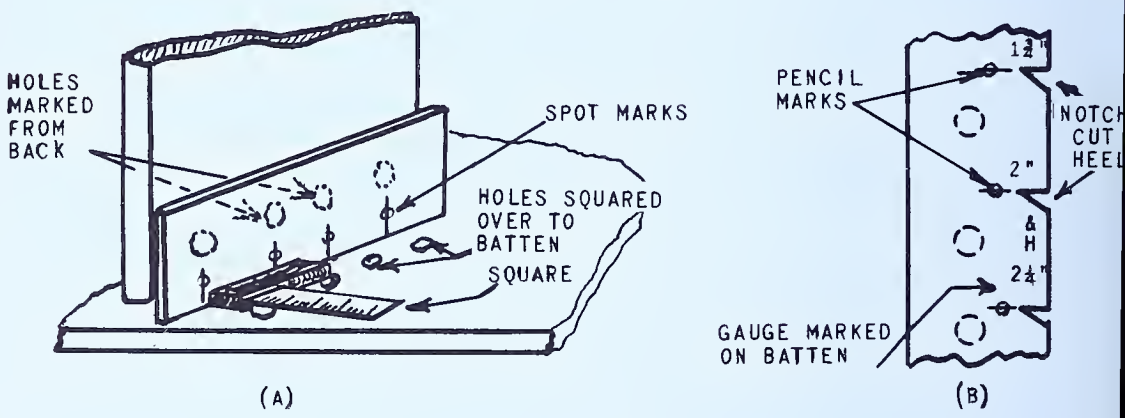


Fig. 92--Squaring Holes Over to Batten

erased. (The straight side of the notch is *the location of t hole*). This is especially necessary when the clip is to be fu naced, since the template may become charred.

LAYING OUT FROM SINGLE BATTEN

Before laying out the clip, the spots for the second flan are back-marked, or transferred to the same side of the batt on which the first holes are marked. The batten can then applied to the clip and the holes for the first flange mark through the wood with a wood punch (See Fig. 93).

Without removing the batten, the lines can be drawn on t second flange (with a square) perpendicular to the heel. The ga

is then measured from the heel on each line and a mark made with a center punch.

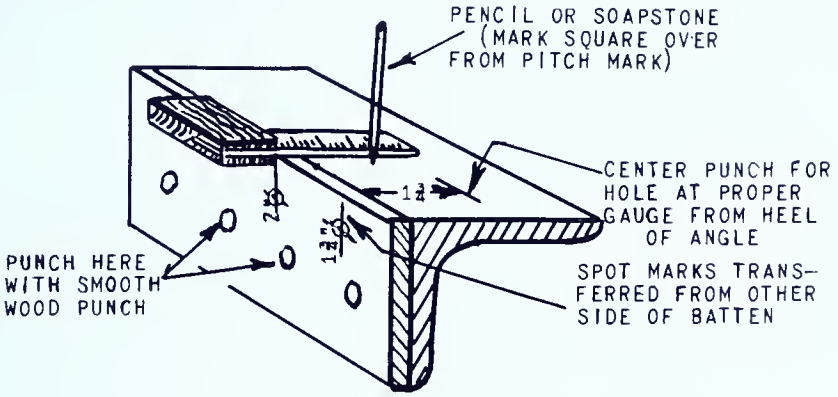


Fig. 93 — Laying out Clip from Single Wooden Batten

Questions

1. Why is the heel location marked on a wooden batten for an angle clip?
2. Why are set marks needed when two separate battens are used for lifting a clip?
3. What are the advantages of using a *single batten* for lifting a clip?
4. Why are notches cut at the edge of a batten to indicate location of holes?
5. What is meant by "back-marking"?

LIFTING BOWED ANGLE CLIPS

In lifting angle clips which have curvature (shape) two ways, the same procedure is used as in lifting bowed liners, excepting the allowance for liner thickness. Usually one flange of the clip is flat and the other flange has a conical shape (as previously explained in the section on bowed liners). The template for the flat flange is made exactly like the roll set for a rolled liner, including set mark. The bevels for the clip are marked at intervals on this template.

The template for the other flange is made from a wide batten and trimmed on one edge to take the shape of the heel of the required bar when laid in place against the plate. A set mark is made on this batten to match the mark on the flat template. (Several set marks should be used if the clip is fairly long.)

The holes are then marked on the batten and other marks added as required. After the clip is furnaced to the correct curve and bevels from the flat template, the other template should be tried

in place before laying out any holes. If this template does not fit smoothly and evenly, the angle itself will not fit on the ship. After the angle is made to fit both templates, the holes are laid out and punched, care being taken to align the set marks so that the holes in both flanges will be right.

Questions

1. What is a "furnaced" clip?
2. What is a "bowed" clip?
3. Why should more than one set mark be used when lifting a long clip or angle?
4. Why are holes not punched in a clip until after the furnacing operation?

TYPICAL TEMPLATE MARKINGS FOR ANGLE CLIPS

Figure 94 shows a sample batten for a small angle with the usual markings needed for laying out the clip.

H -- Heel of clip.

AE -- After end.

H-186-710 -- Hull and charge numbers.

FR 106 Port -- Frame number (port side).

15/16" and 11/16" -- Hole sizes

C.K.O.S. this leg -- Countersink holes on other side after punching for one flange only.

N.O.C.K. -- Do not countersink (referring to the other flange).

ø -- Location mark for rivet holes spotted at heel.

G=2" -- Gauge for rivet holes is 2".

$3\frac{1}{2}$" x $3\frac{1}{2}$" x 3/8" -- Scantlings of angle.

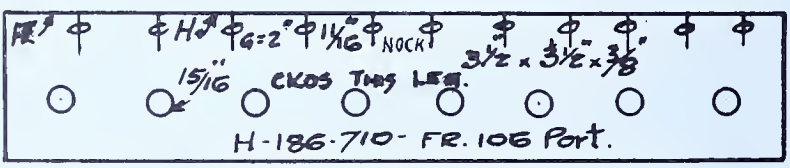


Fig. 94--Template Markings for Angle Clip

ROUGH AND SMOOTH SIDES OF BATTEN

In Fig. 95 is shown a cross section through a typical wooden batten. One side and one edge are planed smooth, while the opposite face and edge are left rough. Marks should all be made on the smooth side whenever possible for accurate measuring. The smooth or straight edge is used at the heel.

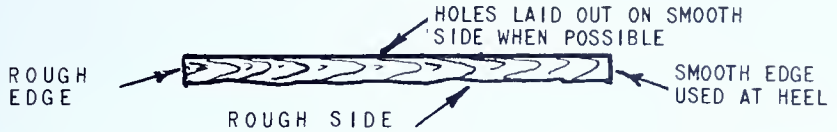


Fig. 95 Cross Section of Wooden Batten

BRACKETS AND SMALL FLANGED PLATES

When two structural members of a ship, (such as deck and shell) meet each other at right angles, or nearly so, it is necessary to stiffen the connection to prevent racking, or transverse distortion shown in (B), Fig. 96. For this purpose brackets are fitted, as shown in (C) and (D). These brackets are sometimes riveted and sometimes welded. They may be flanged as shown, or perfectly flat, depending on their size and on the forces expected. Bracket sizes and thicknesses, flanges, number of rivets required, etc., are indicated on the drawings to agree with strength requirements. Most brackets are made in the shop from mold loft templates, although occasionally brackets have to be lifted.

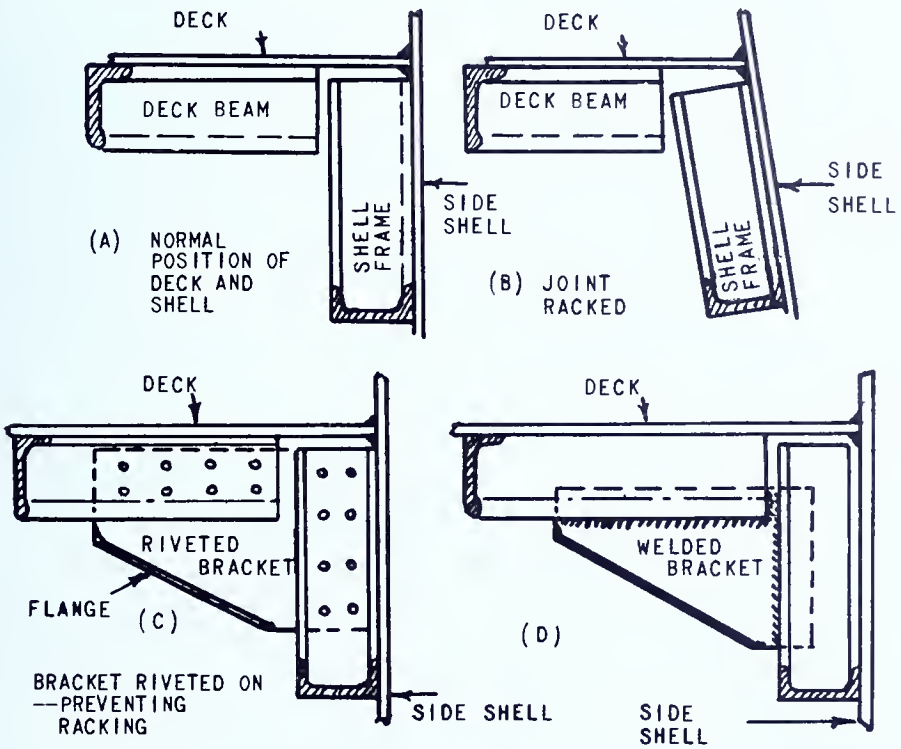


Fig. 96 – Bracket Connections

How to Lift a Flat Riveted Bracket

PROCEDURE:

1. Clamp or hold a flat piece of strawboard in the location of the required bracket.
2. With a pencil mark on the template the location of the necessary rivet holes.
3. Mark on the strawboard the location of the toes and ends of stiffeners, or other members, to which the bracket must be connected.

   This will help determine the location of the sheared edges.
4. Remove the template and backmark or punch through all necessary markings.

   The marks on the opposite side of the template are backmarked so that all markings will appear on one side of the template.
5. Mark on template any identification necessary for proper location and installation of bracket.
6. Procure a flat plate of the required thickness and size.

   Bracket thickness may be obtained from the blue print. The plate used must be sufficiently large to permit laying out bracket with proper landing for rivet holes.
7. Lay the template on the plate, leaving room for the required landings for all holes.

   The minimum landing is 1-1/2 times the rivet diameter, but it is usual to add 1/8" in the event it might be necessary to later increase the size of rivets.
8. Punch hole centers through template, thus transferring location of holes to the plate.
9. Mark outline of bracket on plate, as illustrated at (B), Fig 97.

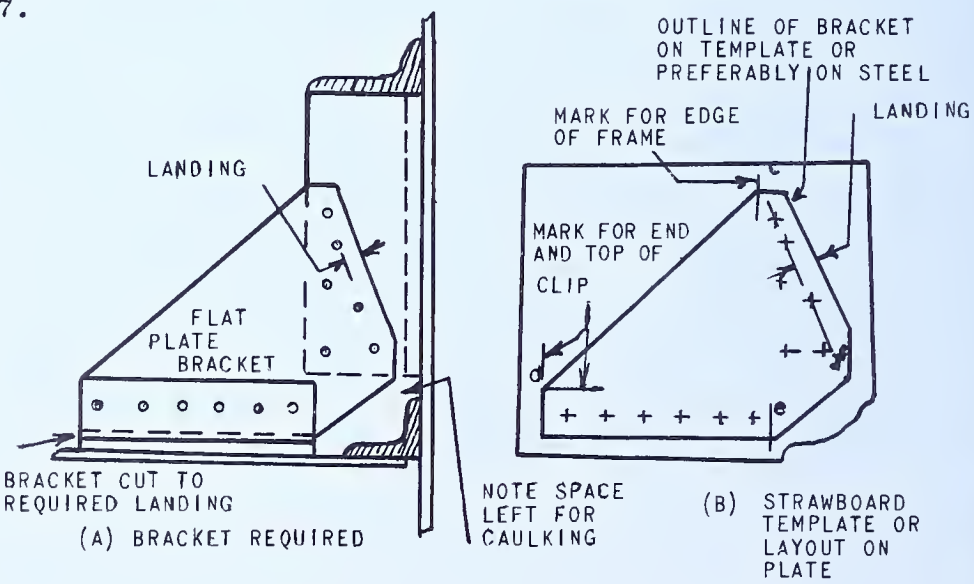

LANDING
FLAT PLATE BRACKET
BRACKET CUT TO REQUIRED LANDING
(A) BRACKET REQUIRED
NOTE SPACE LEFT FOR CAULKING
OUTLINE OF BRACKET ON TEMPLATE OR PREFERABLY ON STEEL
MARK FOR EDGE OF FRAME
LANDING
MARK FOR END AND TOP OF CLIP
(B) STRAWBOARD TEMPLATE OR LAYOUT ON PLATE

Fig. 97—Detail of Flat Bracket

The corners of the flat bracket are marked to come at the ends or the toes of the clip and frame, as at "c", "d", "e" and "f" in the drawing. (This is true only for a flat bracket). In Fig. 97 (A), the frame and the clip, as well as the bracket, are kept well clear of the toes of the gunwale angle or deck stringer angle. This is to allow room for a caulking tool. The bracket is cut to the required landing at the clip for the same purpose; that is, to allow for caulking around the deck flange of the clip.

10. Transfer identification marks from template to bracket.
11. Have bracket sheared and punched.
12. Install bracket in place on ship.

FLANGING A BRACKET

When a flange is needed on a bracket, certain precautions must be taken because of the radius, or curvature, along the surface where the plate is bent. In Fig. 98 is sketched the appearance of a section cut through a bend in a plate. At "a" is marked the center of the curved part, or bend line. This is the line upon which the die is placed when flanging the plate. The radius of this die is about 5/8". For this reason, the plate is always curved for a small distance "ac" and "ab" on each side of the bend line.

The bend line, therefore, must be raised from the point "e" on the template (See Fig. 98) so that this curvature will not foul the frame. The distance from "e" to "a" on the template usually is made an inch and a half, as in almost all cases this will keep the bend clear of the frame. (Sometimes, however, this must be increased to two inches or more, if the bend line is nearly perpendicular to the bracket edge).

Questions

1. Why are deck beams usually bracketed to shell frames?
2. How are bracket sizes determined by the shipfitter?
3. What is the standard landing for rivet holes in a flat bracket?
4. How is allowance made for radius of bend when lifting a flanged bracket?
5. What is a bend line?

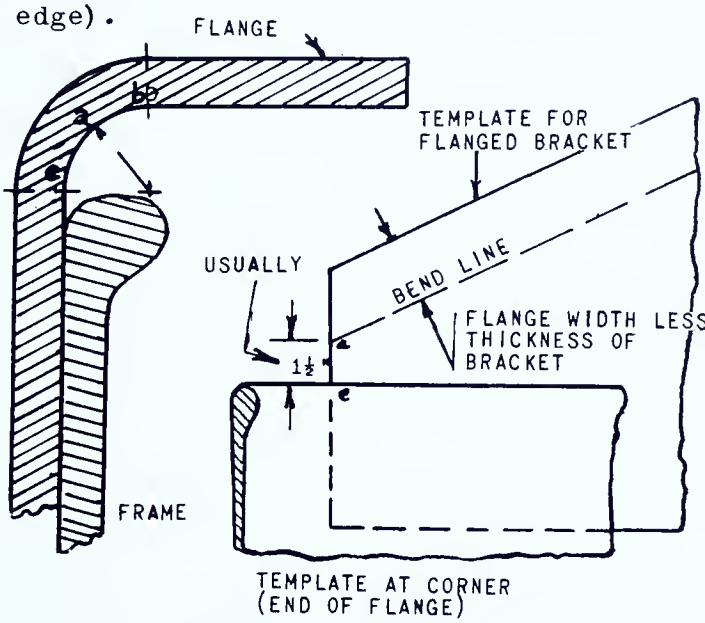


Fig. 98 -- Enlarged Section of Bracket After Flanging

FLANGING FLAT PLATES

When a plate is flanged, the only part which does not chang in length is the neutral surface. The dashed lines in Fig. 99 sho the neutral surface or center of thickness of the plate. Thi surface does not change its dimensions when the plate is rolled o flanged. For this reason, holes laid out on either face of th plate before bending will have the same spacing after bending provided they are measured along the neutral surface.

To make use of this fact, we must find the exact spacing we need from hole "a" to hole "b" (or from hole "c" to hole "d") *along the neutral surface* as rolled up in its final shape. This spacing can be laid out on either face of the plate *before rolling or flanging*. Also, the radius of the bend is so great that the flange width as measured across the outside will be greater than the distance on the neutra surface from the bend line to the edge of the plate. These effect are illustrated in Fig. 99.

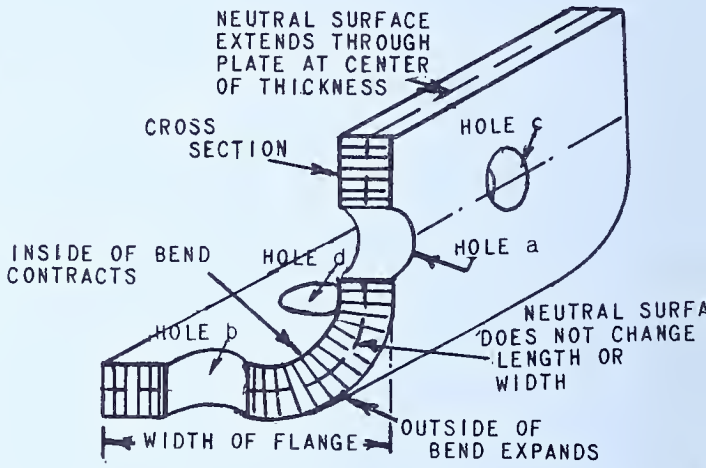


Fig. 99--Neutral Surface

Figure 100 (A) shows a section through a 3" x 3/8" plate. bend line is marked 1" from one edge and is of course 2" from th other edge. The plate is then flanged, using a *standard* 5/8 *radius* for the inside of the bend. The section then appears as a (B) in Fig. 100.

The neutral surface is still 3" long, although the widths of the two flanges are 1-3/8" and 2-3/8" respectively, when measured from the flat side of the plate as in the sketch at (B). The effective length of each flange "grew" 3/8 of an inch, or an amount equal to the thickness of the plate, over the original measurement from the bend line to the edge.

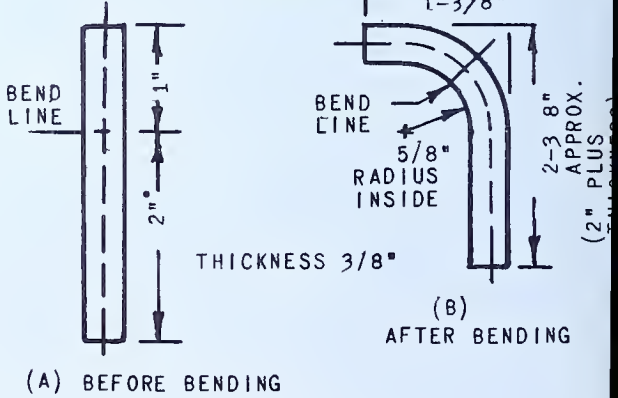


Fig. 100--Section Before and After Flanging

When the bend line for a flanged bracket has been already determined as on the template in Fig. 98, the distance from this bend line to the shear mark for the edge of the flange should be *less than the required width of flange by the thickness of the plate.* That is, if a 3" flange is desired on a 1/2" plate, the distance from the bend line to the shear line must be 2-1/2". Remember that the foregoing applies only to standard flanging dies of 5/8" inside radius, which are used on plates from 3/8" to 9/16" thick.

Sometimes a flanged plate must have rivet holes in both flanges. Although this eliminates the use of a clip, it brings up a problem in laying out the rivet holes, since there is no exact heel from which to measure. In certain cases it is possible to flange the plate first, and then lay it out, punch it, and shear it. For many flanged plates, this cannot be done, and the holes must be laid out and punched, and the edges sheared before flanging.

The width of a flange is measured from its edge to the assumed heel line of the plate or other flange, as shown in Fig. 100 (B). Rivet hole gauges must be measured from this same heel line, as illustrated in Fig. 101 ("x" to "z" is the gauge).

It is obvious that the required gauge "xz" cannot be laid out full length from the bend line on the plate before flanging, because of the amount gained in rounding off the corner.

If the center of the rivet hole is at "c", the gauge distance is "xz". However, the distance which must be laid out from the bend line to the rivet hole is the distance from "a" to "c" along the neutral surface. The difference between these two distances (that is, "xz" minus "ac") is the amount the rivet holes would have to be pulled toward the bend line when laying out the steel. This difference depends only upon the thickness of the plate and radius of the bend. From Fig. 101, the following formula for determining rivet gauge is derived:

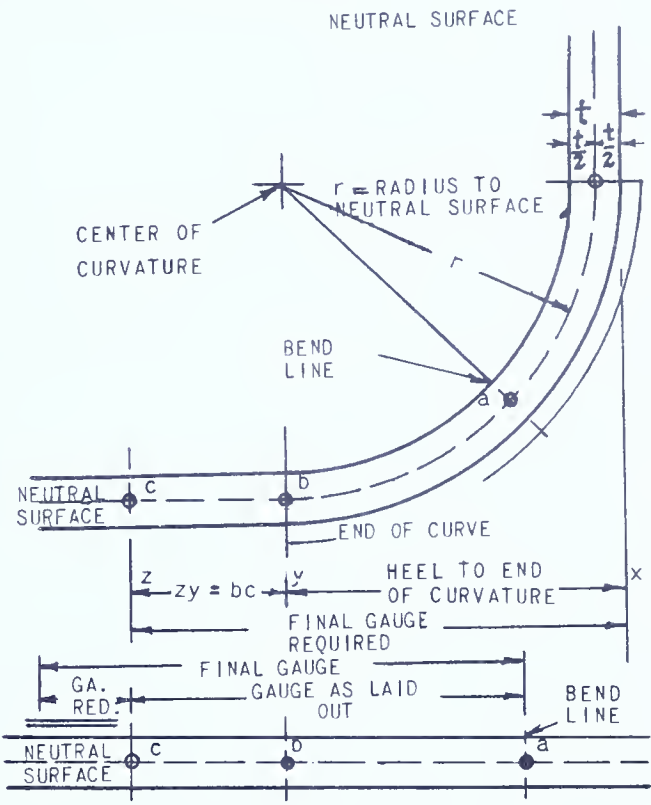


Fig. 101 -- Section Views of Flanged Plate and Layout Before Bending

In Fig. 101, the gauge required after flanging is "xz". The reduced gauge (or distance to bend line before flanging) is "ac"

(measured along the neutral surface). The reduction in gauge i "xz" minus "ac". Because this part of the plate is flat, "bc" i equal to "yz". Therefore, the gauge reduction is "xy" minus "ab" which we must find in terms of the radius and the thickness of th plate.

Again referring to Fig. 101, "r" is the radius to the *neutra surface*, and "t" is the thickness of the plate. The distance "xy is the same as $r + \frac{1}{2}t$, which can be calculated easily.

The plate is flanged over to a right angle, or 90 degrees. Th distance along the neutral axis from "d" to "b" is one-quarter o a circle. The length "ab" is half of "db", or one-eighth of th circumference of a circle whose radius is "r". The whole circum ference of the circle is $2\pi r$. Therefore: Distance "ab" is 1/8 o $2\pi r$, or $1/4\pi r$. The required gauge reduction "xz"-"ac" is th same as "xy"-"ab", which reduces to $(r + \frac{1}{2}t) - \frac{\pi r}{4} = \frac{3r}{14} + \frac{t}{2}$

The formula for reducing the gauge or rivet holes (or othe marks) from the bend line when laying out a flanged plate is

$$\textit{Gauge Reduction} = \frac{3}{14}r + \frac{1}{2}t$$

Example: The gauge reduction for use when flanging a 3/8" plat to a 5/8" inside radius (90 degrees) is required.

Gauge Reduction = 3/14r + 1/2t
t = plate thickness
r = inside radius + 1/2 plate thickness
r = 5/8" + 3/16"
r = 13/16"
t = 3/8"

Gauge Reduction = (3/14" × 13/16") + 3/16"

Gauge Reduction = 39/224" + 3/16"
= 3/8"

This is the same reduction which was found necessary for t flange width in the explanation of the 3/8" plate shown in F 100. With the standard die (5/8" inside radius) and plates 3/8" 9/16" in thickness, the reduction comes very close to being t thickness of the plate.

As another example, consider the plate sketched in Fig. 10 The inside radius is 2-3/4", and the plate thickness 1/2".

Therefore r = 2-3/4" + 1/4" = 3"
t = 1/2"

Gauge Reduction = 3/14r + 1/2t
= 3/14 x 3 + 1/4
= 9/14 + 1/4
= 25/28 or 7/8" (to nearest sixteenth)

The rivet holes must, therefore, be pulled toward the bend line 7/8" from the final gauge required. The same condition holds true on the other side of the bend line, or other flange of the plate. To hold the proper gauge after flanging, the holes must be pulled toward the bend line (or the bend line pulled toward the holes) an amount equal to the gauge reduction, which in this example is 7/8".

Questions

1. What happens to the neutral surface of a plate, when the plate is flanged?
2. What is meant by the "gauge" of rivet holes in a flange of a plate?
3. What is meant by "gauge reduction"?
4. A 7/16" thick bracket requires a $2\frac{1}{2}$" flange. What is the flange width as laid out from bend line to sheer mark, if standard flanging dies are to be used?
5. What is the gauge reduction necessary when laying out holes in a $\frac{1}{4}$" plate to be flanged with an outside radius of 4"?

LIFTING A FLANGED PLATE

The principles embodied in lifting a flanged plate are illustrated in the procedure. It should be noted that this sheet refers to riveted construction.

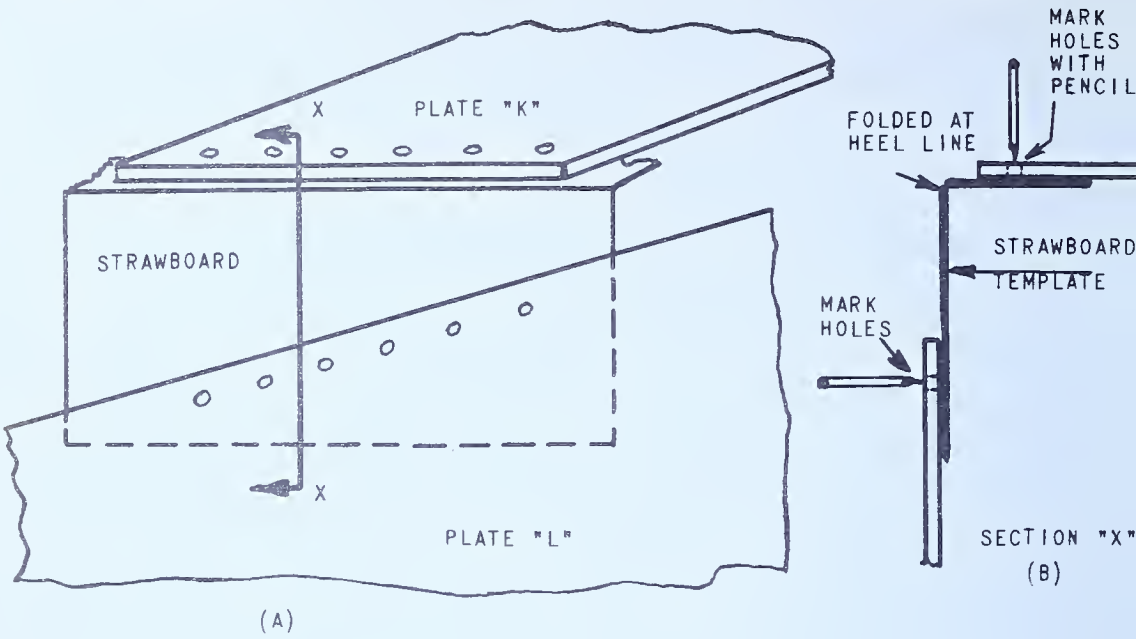
A flanged plate connection is to be lifted for connecting plate "K" to plate "L", as illustrated in Fig. 102.

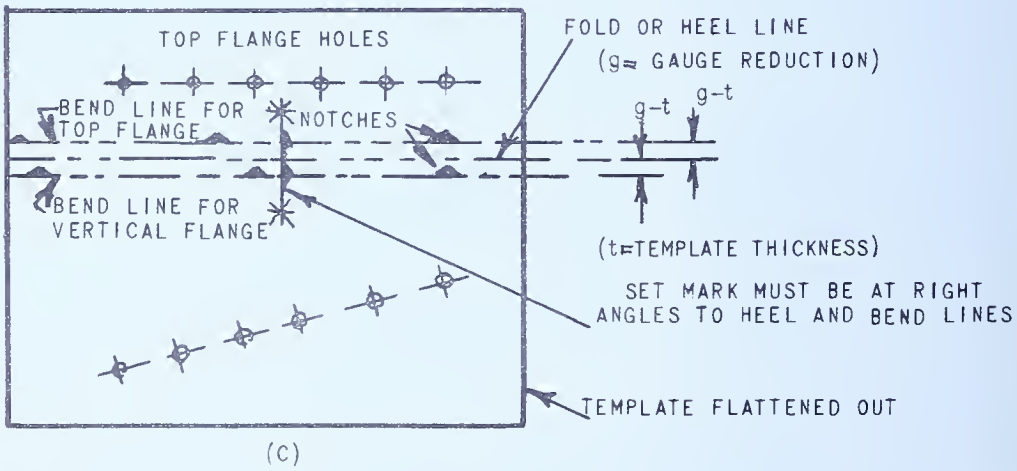
How to Provide for Gauge Reduction When Lifting a Flanged Bracket

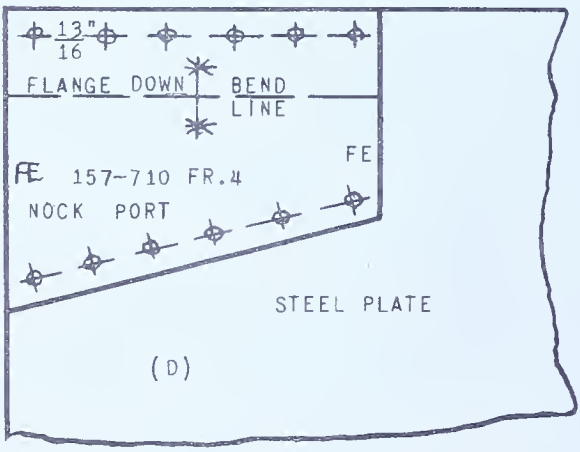
PROCEDURE:

1. Cut a piece of strawboard large enough to form a template of the required flanged plate. See Fig. 102, (A).
2. Score and fold the strawboard and hold or clamp in position against the two adjoining plates.

   The fold should be at the heel line, as illustrated at (B), Fig. 102.
3. On the template, mark the location of rivet holes.
4. Open template and lay on a flat surface as at (C), Fig. 102.
5. Determine gauge reduction, using the following formula:







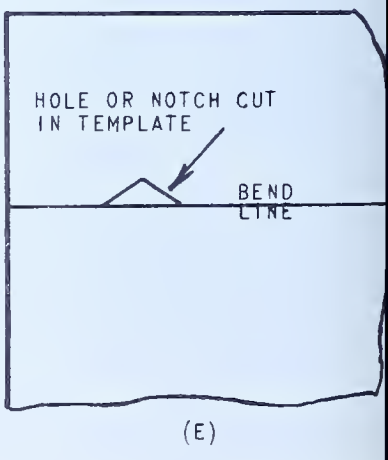


Fig. 102—Lifting Flanged Bracket with Holes in Both Flanges

$$\text{Gauge Reduction} = \frac{3}{14}r + \frac{1}{2}t$$

Gauge reduction is the distance each hole must be pulled *toward the bend line*, when laying out a flanged plate.

r = radius of bend to neutral surface of plate.
t = thickness of plate.

6. Reduce the gauge by drawing a *bend* line on each side of the fold in template (heel line). The distance from the heel line to each bend line is the gauge reduction as determined in step "5", minus the template thickness, since a folded template is used. Fig. 102 (C) shows two bend lines, each moved the proper distance from the heel line of the template. Each of these is used at the single bend line on the steel, when corresponding flange is laid out.

7. On the template, mark a set line perpendicular to the bend line, as shown in Fig. 102 (C). (The use of set marks prevents the longitudinal misalignment of lifted holes).

8. Notch each bend line at intervals. Also, notch set mark at bend lines. These notches are used in aligning the template with the bend line, on the steel, when laying out the plate, as illustrated in Fig. 102 (C).

9. Secure a steel plate of proper thickness and of sufficient size to make the required member.

10. Lay out on the steel the location of rivet holes in one flange of the plate, taking care to hold the proper landing at the edge and at the end.

11. Using the notches in the template, mark the bend line for this flange.

    The bend line nearest the flange being laid out must be used.

12. Remove the template and mark a continuous straight line, connecting marks made through notches in template. This line on the steel will be the *actual bend line* which will be used in flanging the plate.

13. Replace template, setting the second flange bend line, by means of notches cut in template, on actual bend line previously laid out.

14. Mark on steel location of holes on second flange.

15. Determine proper landing, (1-1/2 times the diameter of rivets) and mark outline of bracket on plate.

16. Add necessary markings for identification of member.

    Mark "flange up", or "flange down" at bend line, as required. Note: In the example illustrated in Fig. 102 (D), the plate is marked "flange down."

17. Have plate sheared, punched, and flanged, ready for instal lation on ship. It should be noted that flanging the plate *or down* does not affect the amount of gauge reduction fo laying out the holes. When the holes are punched with th plate flat, the spacing is correct at the neutral surface and this will not change when the plate is being flanged. other words, a bracket can be laid out on either side with th same template and same position of the bend lines. It i necessary, however, that the bracket be flanged the proper wa after being laid out so that it will fit in place on the steel That is, if a "right-handed" bracket is flanged the wrong wa it will be "left-handed".

FITTING WELDED BRACKETS

In lifting brackets for welded work, the amount of overlap given by the following rule:

Minimum lap = 2t + 1" (A.B.S. rule) where "t" is the thickness the lighter plate. The application of this rule is illustrat in Fig. 103.

Figure 104 shows brackets welded directly to a deck plate and a bulwark plate with a double fillet weld.

The corners "c" and "d" of the flat bracket at (A) are always cut back at right angles to the shell and deck plates for a distance of one inch. This gives a better appearance; it also results in a stronger weld than would be obtained if a sharp edge were used. The corner at "e" is sheared off two inches on each side, to allow for drainage, and also to permit welding the deck to the shell behind the bracket.

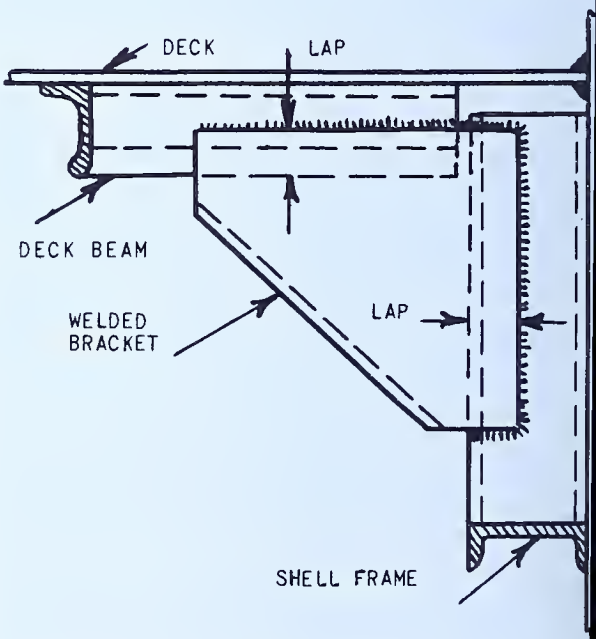


Fig. 103--Welded Flanged Bracket

The flanged bracket at (B) has the corners "f" and "g" cut at right angles to the deck a shell to clear the radius of the flange.

The bend line is kept 2" from the deck at "f" rather than t usual 1½" because of the steep angle at which the bend line mee the deck. (This distance is on the template. The bend line mov closer when the plate is flanged).

The corner at "h" is cut back far enough so that the edge

the plate is entirely clear of the deck stringer angle (at least one-half inch away). This permits room to use a caulking tool on the angle.

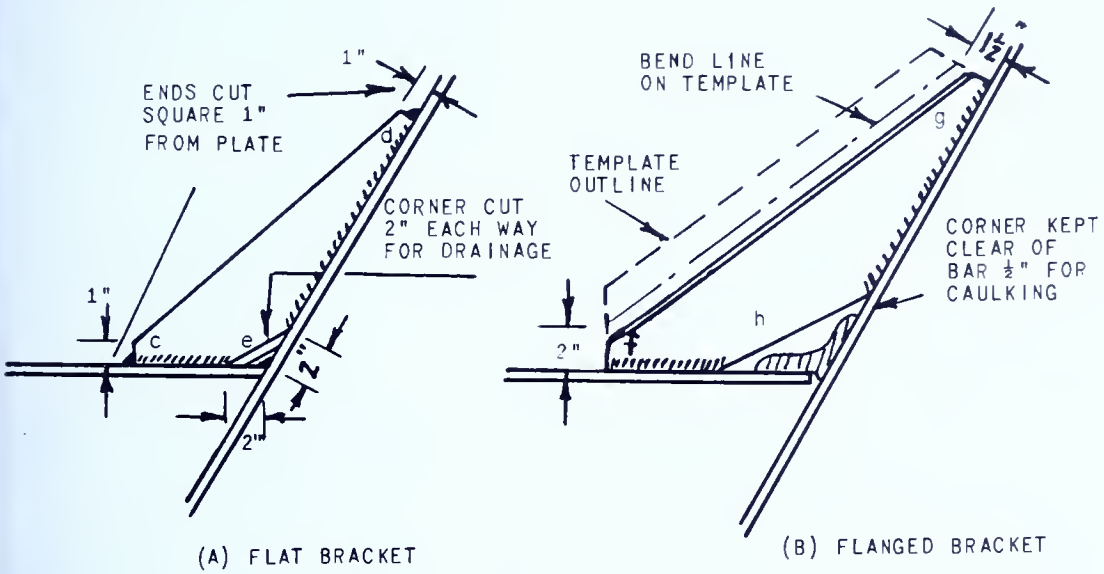
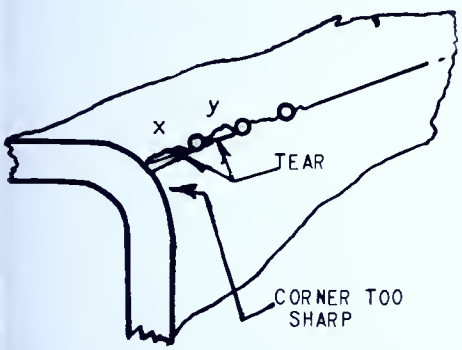


Fig. 104—Welded Bulwark Brackets

PREVENTING FRACTURE

When a plate is laid out in such a way that the bend line would be marked "flange down", no center punch marks should be put on the bend line. The reason for this is that the outside face of the bend is stretched in the process, and the slight indentations made by the center punch marks are sufficient to start a tear in the plate. This is illustrated in Fig. 105, at (x) and (y).



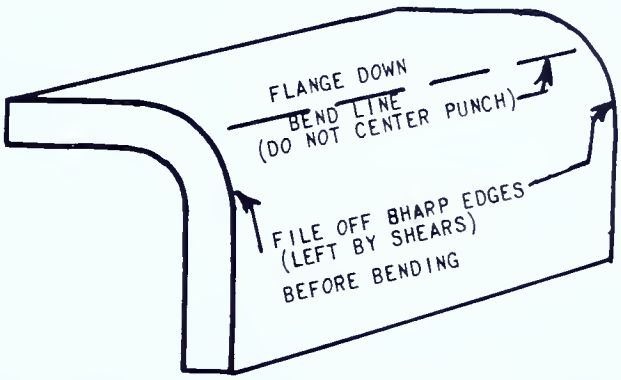


Fig 105—Fracture at Bend Line *Fig. 106 -- Plate After Flanging*

Another consideration in preventing fracture is the temperature of the plate when flanged. If it is cold or frosty there is more chance of a tear or a crack. For this reason, plates should be warmed (near a fire or otherwise) before flanging in cold weather.

When a plate is rolled at the steel mill, it is passed endways through the rolls. The effect of mechanically squeezing it, in

this manner, with the rolls always turning in the same direction, causes a perceptible fibrous structure or "grain" in the steel; that is, the plate will withstand more tension along its length than in a transverse direction. Plates should be laid out, when possible, to take advantage of this condition, with the bend line at right angles to the direction of the "grain". The grain of plate usually is parallel to the longest dimension of the stock plate.

JOGGLING OF PLATES

Joggling is used in a plating arrangement wherein the edge of one plate is offset, or joggled, to lap the edge of an adjoining plate, without the use of liners. See illustration, Fig. 60, page 40

When a bracket or other plate is joggled *cold* in the joggling machine, it is not necessary to make any allowance for "draw" or "creep" of the plate, providing the offset of the joggle is not greater than the thickness of the plate. The steel at the joggle is actually stretched, and the length "e" of the plate will be the same after joggling as before.

If the plate is *hot* when joggled, this rule will not hold. Also, it has been found that the *length will vary* if the joggle offset is greater than the plate thickness. For such a joggle, a scrap piece of steel should first be tried in the machine to find out how much it will draw. The proper allowance can then be made when laying out the plate.

Questions

1. What is the standard lap for welded brackets?
2. Why are the corners "c" and "d" in Fig. 104 cut back for a distance of one inch?
3. Why is the cut-back indicated in question "2" increased when the bracket has a flange?
4. What may be the result of center punching a bend line?
5. What is the effect of temperature on a plate being flanged?
6. What is meant by the "grain" of a steel plate?

FITTING COLLARS AND SPACERS

When a continuous bar, such as a shell frame or a shell longitudinal, passes through a watertight deck or bulkhead, the hole or notch cut in the plate must be closed and made watertight. This is done with a "collar", as shown in Fig. 107 (A) and (B). The purpose of this collar is merely to close the hole. It has no effect as a strength member, except possibly to prevent the *corners* of the notch from tearing, owing to concentration of stresses.

At (A) is a notch cut in a deck plate through which a channel shell frame is to pass. The notch is wider than the channel flanges, and after regulating, the hole is open at both the heel side and the toe side. This hole is closed with a two-piece collar as shown at (B). The piece "x" is shaped to fit inside the channel and to

lap over the plate with the standard lap for welding (Lap 2t+1"). The piece "y" is fitted tight against the heel of the channel, and made wide enough to give the standard lap on the deck plate. If the notches fit closely at heel and toe as shown at (C) in Fig. 107, a single-piece collar can be used as at (D). The thickness of the collar is the same as that of the plate on which it laps.

If several such notches are cut consecutively, as in the case of deck beams passing through a passageway bulkhead, it is usual, for appearance, to make all collars look the same. For this reason,

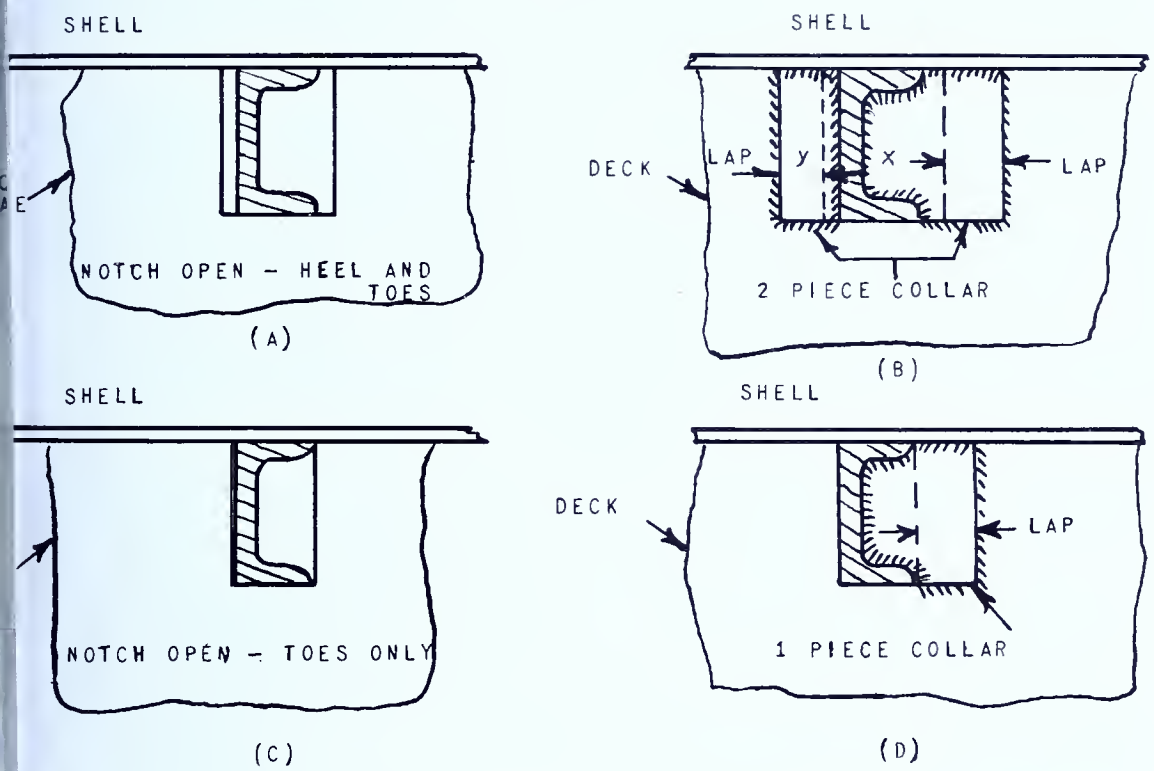


Fig. 107 -- Shell Frame Collars at Decks

A suitable collar is made for the widest notch, and the same size collar used for all beams in the same passageway, although most of the laps may exceed the standard given by the formula. For the same reason, collars for passageways should be placed on the passage side of the bulkhead, rather than in the rooms.

Collars on watertight bulkheads should be on the "face", or caulking side, so that any leaks may easily be stopped when testing for watertightness. Collar locations should always be checked with the drawings.

If the beams or frames are to be hidden by ceiling or sheathing, the minimum lap should be held for each notch, rather than making all collars wide enough for the widest hole.

In Fig. 108 are illustrated collars for bulb angles and for beveled channel frames. Collars for any other type of bar would be lifted from the job in the same way, holding the minimum lap as previously explained, and cutting the edge to fit neatly and close the hole.

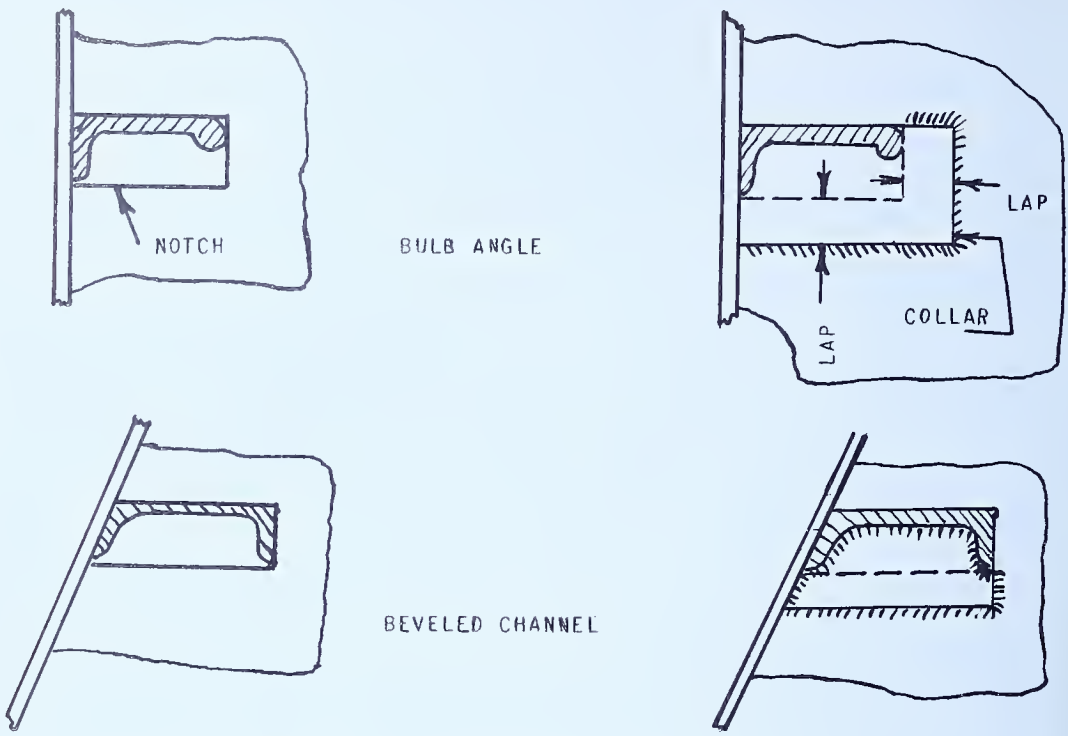


Fig. 108 — Special Frame Collars

Lifting a Collar for a Channel Frame

PROCEDURE:

1. Secure a piece of strawboard slightly larger than the requir collar.
2. Cut strawboard to approximately the shape of the inside of t channel.
3. Fit strawboard template closely to channel, trimming whe needed to secure a close fit.

   The securing of this shape is a "cut and try" process, a though final fit may be obtained by marking close to the cha nel, with a pencil.

3a. If a square-cut end of the channel frame is accessible, or a scrap piece of channel of the same cross section is avai able, place a piece of strawboard against the end of the cha nel, tapping the outline of the required template with hammer.

4. Cut edges of strawboard to provide required lap.

5. If necessary note required dimensions of rectangular pla collar for the heel side of the channel.

6. Lay out collar on steel plate of proper thickness, burn, shear, and install on ship.

Note: Before the general use of welding, such holes were closed with "staples", furnaced bars, or plates, flanged and bent to fit tightly around the frame, or beam, and riveted to the beam and to the plating (See Fig. 109).

This staple, in the instance shown, is merely a continuation of the deck boundary, or gunwale angle. The toes and butts of the staple must be caulked.

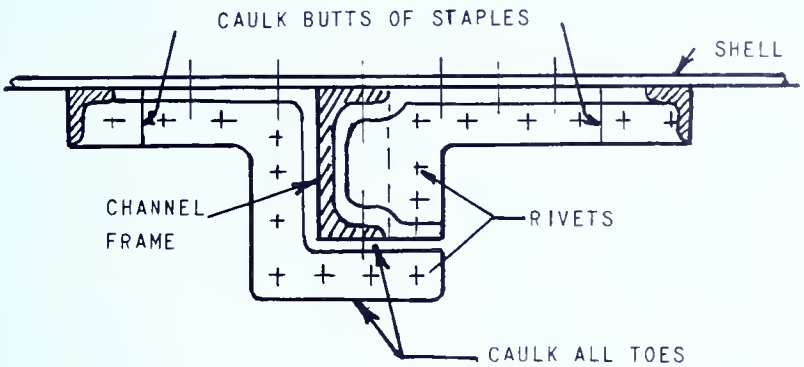
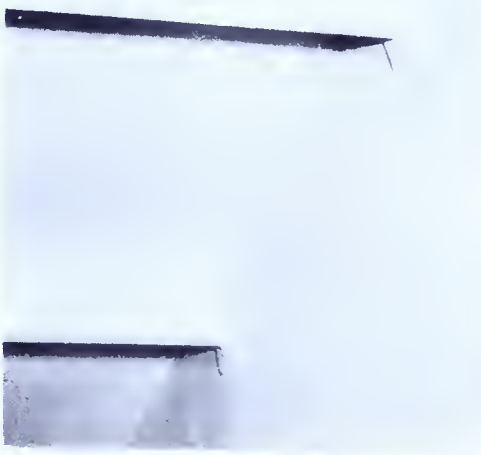


Fig. 109 -- Staple Around Channel Frame at Deck

In building modern ships these staples are obsolete, owing to their great cost as compared with welded collars.

FITTING SPACERS

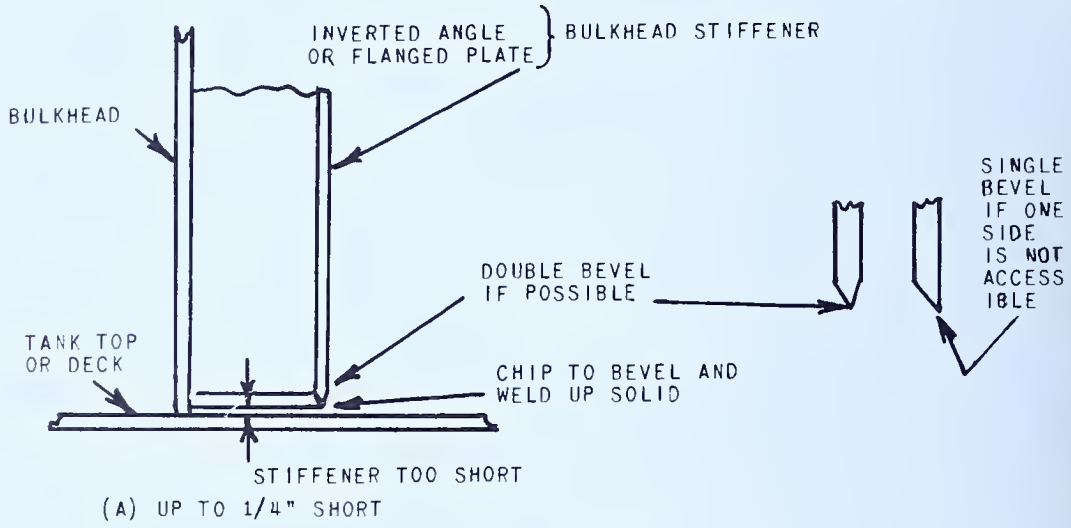
Occasionally it is found that a shell frame, deck beam, or other stiffener (whose end is to be welded to a plate) is slightly shorter than it should be, and does not quite make contact with adjacent members. This might be caused by inaccuracy in laying out or cutting, by contraction of welds, or by extra trimming, owing to some unforeseen difficulty in erecting the steel.



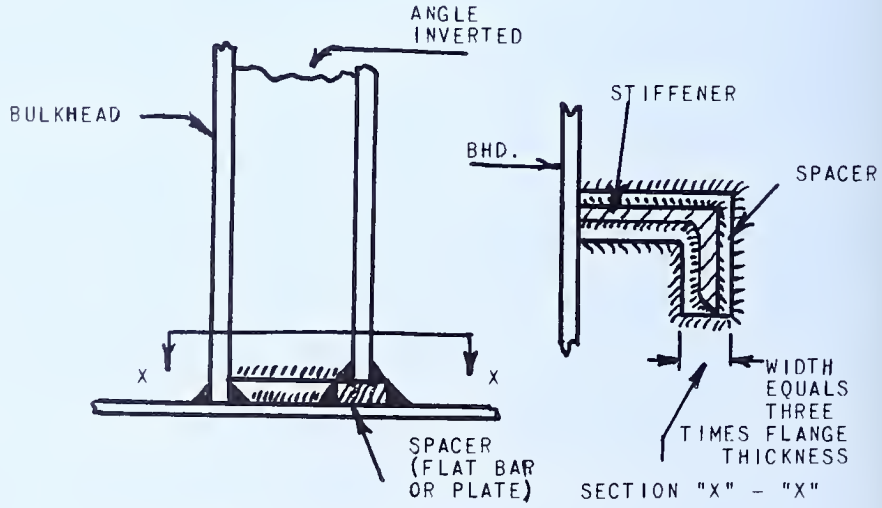
View Showing Collars Around Deck Beams

If the end of the stiffener is not more than 1/4" from the plate, it can be bevel-chipped and the space welded. See Fig. 110, (A). If the end of the stiffener is 1/4" to 1-1/2" from the plate, a spacer can be installed as shown at (B) in Fig. 110. The width of the spacer should be three times the flange thickness (to get a proper fillet weld inside and outside the flange) and should be thick enough to fill the space. Fillet welds all around the spacer at the bottom carry the stress from the stiffener and spacer to the plate.

If for any reason the opening is greater than an $1\frac{1}{2}$", the angle or other stiffener should be cut off square about six inches back from the plate, and a short piece of bar (of the same section dimensions as the stiffener) should be welded in to fill the space. See Fig. 110, (C). The two bars should be beveled and butt welded together. For openings over 1/4" the leader should always be consulted, because of variation in requirements of different owners.


INVERTED ANGLE OR FLANGED PLATE
BULKHEAD STIFFENER
BULKHEAD
SINGLE BEVEL IF ONE SIDE IS NOT ACCESS IBLE
DOUBLE BEVEL IF POSSIBLE
TANK TOP OR DECK
CHIP TO BEVEL AND WELD UP SOLID
STIFFENER TOO SHORT

(A) UP TO 1/4" SHORT



(B) 1/4" TO 1-1/2" SHORT (CONSULT LEADER)

Fig. 110--Spacers for Welded Construction (Continued on Next Page)

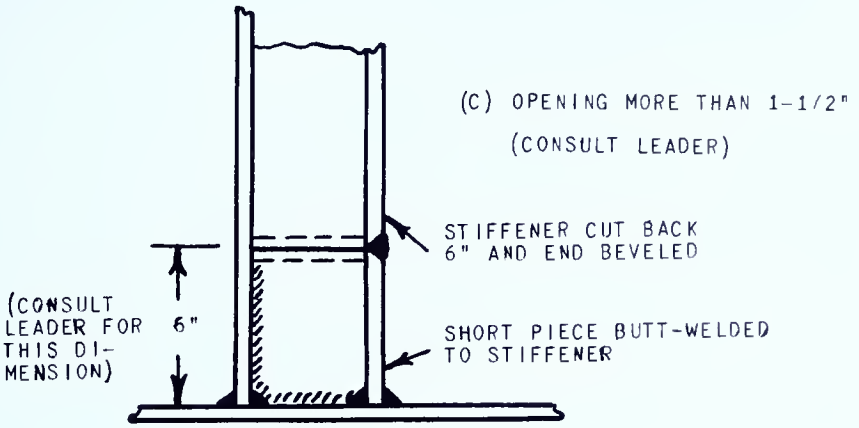


Fig. 110--(Continued from Previous Page).

Questions

1. What is a collar?
2. What thickness of plate should be used in making collars?
3. What is a stapled collar?
4. What is a spacer?
5. What should be done to an inverted angle, or flanged plate stiffener which is short?

PART III

Prevention and Correction of Steel Distortion

PREVENTION AND CORRECTION OF STEEL DISTORTION

As previously explained, the contraction of welded joints when cooling tends to distort the steel. It has been found that if the members are mechanically restricted while the weld cools, the final distortion (after the restriction is removed) will be reduced.

USE OF STRONG BACKS IN WELDING

To reduce the dished effect caused by transverse contraction of a single Vee butt weld, temporary stiffeners or "strongbacks" are tacked across the butt at intervals as illustrated in Fig. 111. They are made of scrap flat bar or plate with a section from 1/2" x 4" to 1" x 6", depending on the thickness of the plates to be butt welded.

Preparing Deck for Final Welding

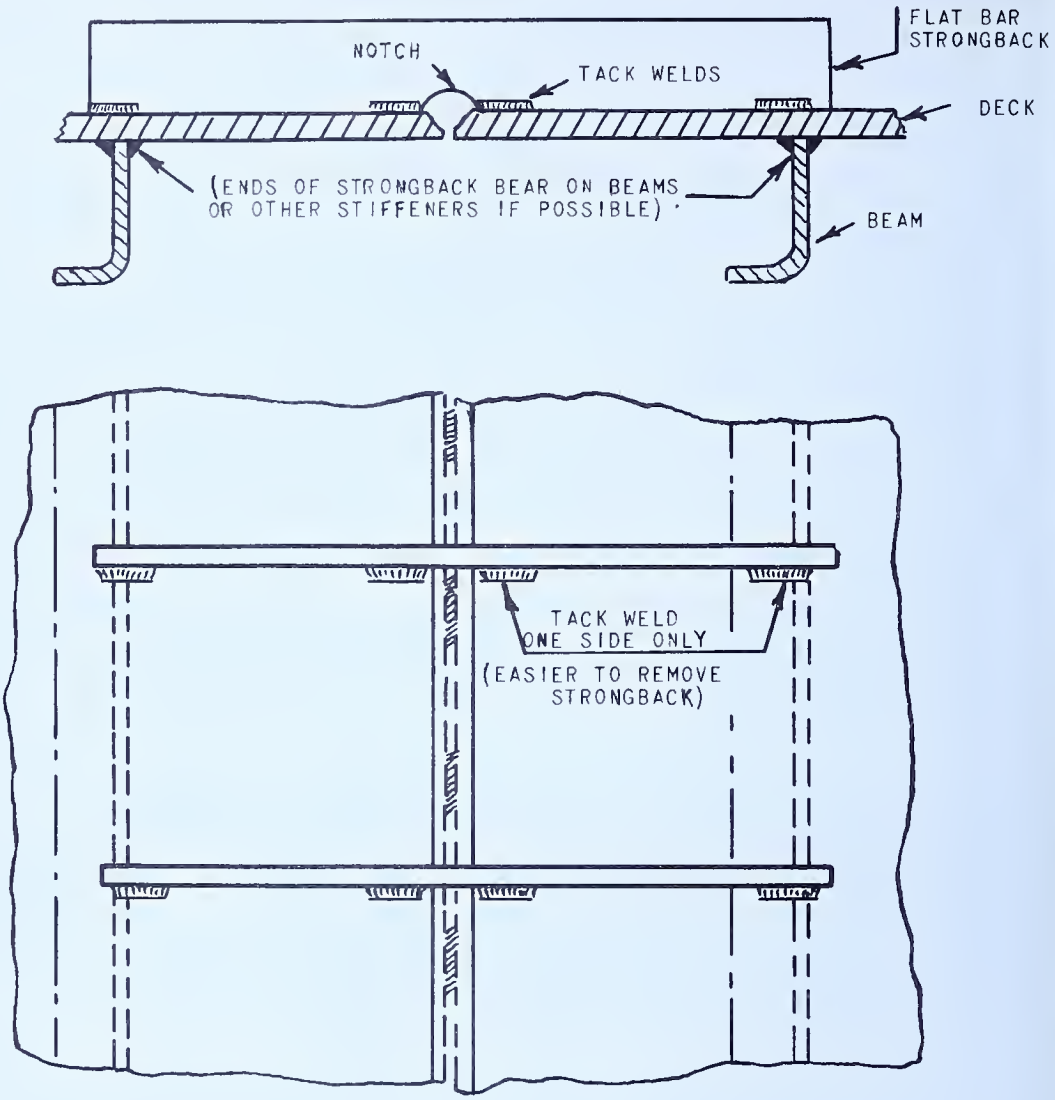


Fig. 111 -- Strongback Used to Restrict Welding Distortion

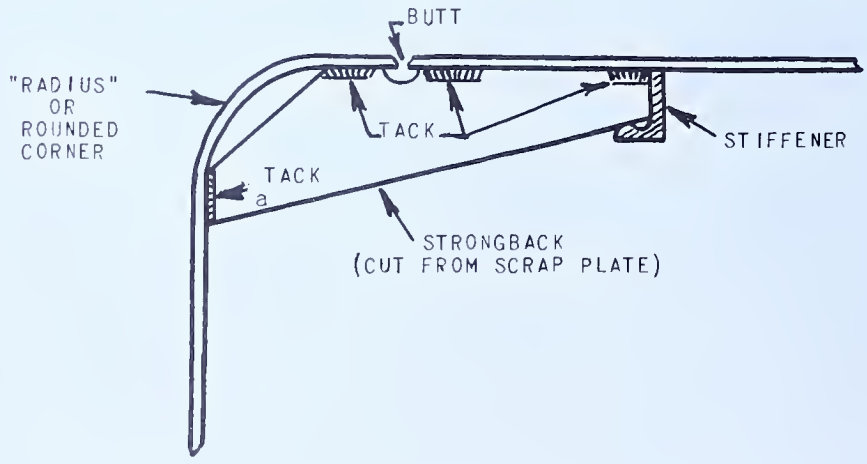


Fig. 112 -- Strongback for Rounded Corner

Strongbacks should be long enough so that the ends bear over deck beams or other stiffeners. They are tacked with four welds on the same side of the flat bar as shown. This makes it easy to remove the strongback by hitting *opposite* the weld with a maul.

On an ordinary butt the spacing of strongbacks should be about two feet. Where a portable automatic welding machine is used on deck butts, the strongbacks must be placed underneath the deck so they will not foul the machine. For shell butts, strongbacks should be placed inside; for bulkheads, they should be located on the stiffener side of the plate, because of the "scars" which are sometimes left when a strongback is removed. (These marks would be more noticeable on the smooth or face side and might require excessive chipping and grinding). When a butt in a bulkhead is very close to a rounded corner, or "radius", the strongback should be made as shown in Fig. 112. It is cut from a piece of plate and shaped as shown so that a tack weld "a" can be placed on the other section of the bulkhead. This has the same effect as putting the end of the strongback over a stiffener. For plate butts which run at right angles to the beams or stiffeners, the spacing of these stiffeners generally is close enough so that no additional strongbacks are required.

In many cases, however, there is a row of butts in the deck longitudinals very close to a butt in the plating. The ends of these longitudinals are in general practice not welded until after the plates have been welded, which means that they will not stiffen the butt sufficiently to prevent welding distortion. Under such conditions, a heavy strongback is used, made from an I-beam or a heavy channel. It should be sufficiently long so that each end is over a rigid strength member, such as side shell, longitudinal bulkhead, or center deck girder. Figs. 113 and 114 illustrate the use of this type of strongback.

The I-beam is set across the deck and its ends bear on the side shell and on the longitudinal bulkhead. With yokes and wedges the deck is pulled up and packed under the I-beam to the proper camber. The strongback is left in this position while the butt is welded. The loose ends of the longitudinal are tacked, but are not welded solidly until the butt has been finished.

CORRECTION OF DISTORTION WITH STRONGBACK

In spite of the precautions taken to prevent distortion, there usually are some members on a ship which are unfair; that is, they have bumps or twists which are objectionable. The removal of these bumps etc., is called fairing. Fairing also includes the straightening of bumps caused by the impact of some heavy object striking the ship.

Experience has shown that a bump caused by mechanically hitting the steel is generally easier to straighten than one caused by excess local heating or by welding contraction. The former can usually be taken out cold (that is without heating) by pushing or

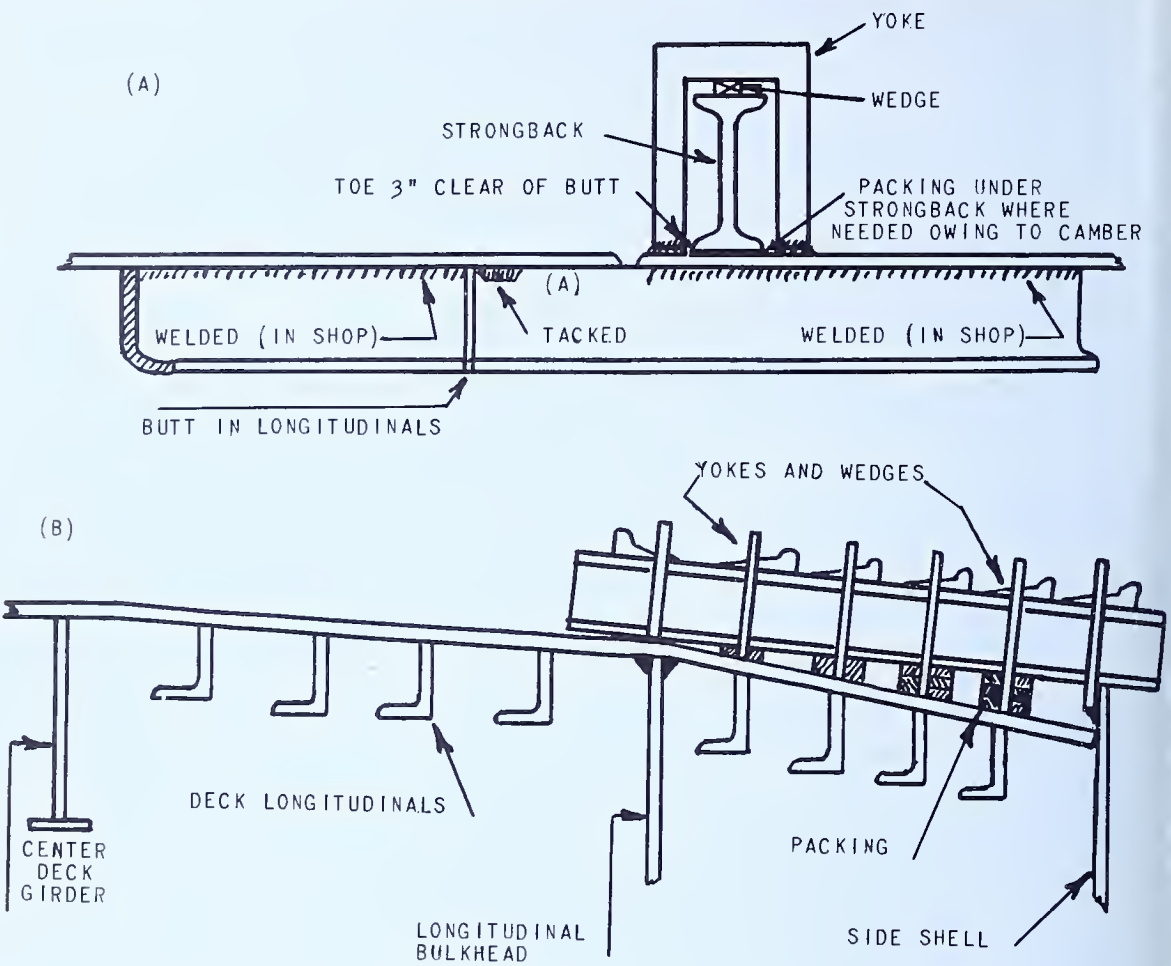


Fig. 113 -- I-Beam Strongback

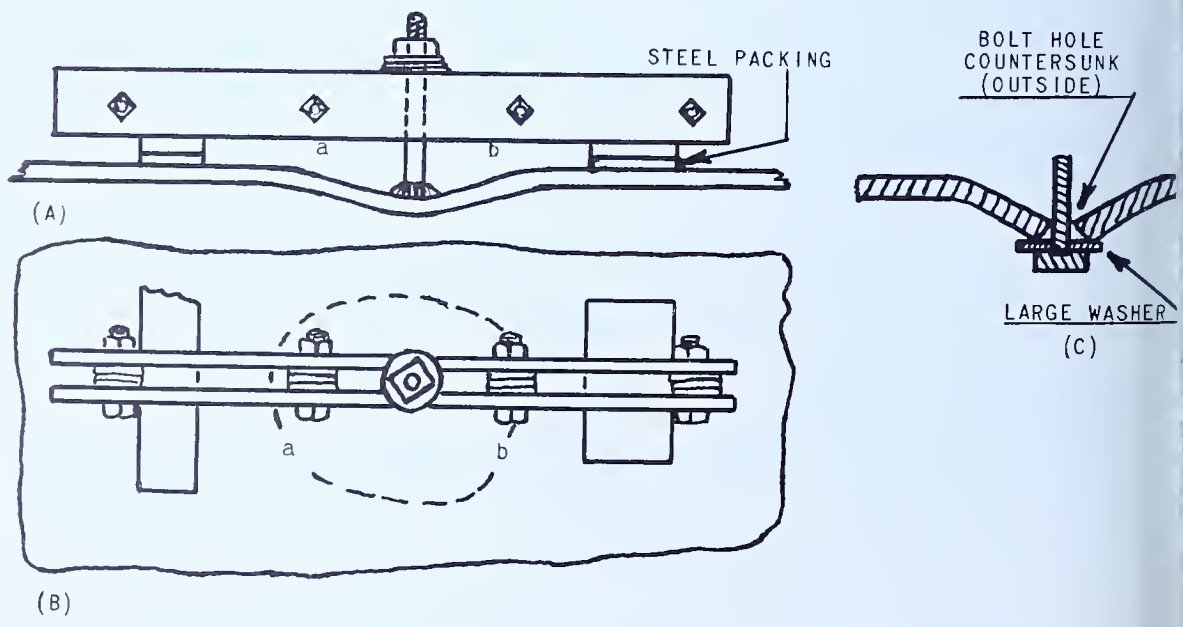


Fig. 114 -- Strongback for Fairing Bumps

pulling with a jack or a strongback. Fig. 114 shows how a strongback can be rigged to pull out a small sharp bump in a shell or deck plate.

A long bolt is welded at the center of the hollow and a strongback set up as illustrated, with packing under the ends to keep it clear. This strongback can be made of two flat bars bolted together, with washers between them as spacers. When a strain is taken on the bolt (by tightening the nut) the center of the hollow comes part way into place, and around the edges of the bump, as at "a" and "b", there will be a very slight knuckle or high place. The fitter, by hammering on this knuckle, can flatten it into place and, at the same time, relieve the strain so the plate will remain smooth and fair.

Caution: When it is necessary to hammer or maul the surface of a plate, a flatter should be used, or the pounding done with a ball-faced maul. Otherwise the surface would be sharply indented and would present a very poor appearance.

The detail at (C), Fig. 114, shows how the bolt is applied to a very deep, sharp bump. A hole is drilled through the plate slightly larger than the bolt and the hole is then countersunk on the outside or convex side. The head is left on the bolt, and the strongback used as before. When this bump is pulled up into place, the countersunk part of the hole usually will be found to have closed, leaving a cylindrical hole in the flattened plate. This hole can be welded when the job is completed. In some cases, several holes must be drilled to give the excess metal room to work toward the center. Remember that when straightening out bumps with strongbacks and bolts it often is necessary to use two or three bolts in one strongback to get the required force, and in some cases, several strongbacks will be needed for a single long bump. This condition generally can be foreseen and equipment arranged in a suitable way.

When the bottom or side shell plating of a longitudinally-framed ship (such as the average tanker) is bumped inward, a special adjustable strongback can be made for use with a hydraulic jack. This is especially handy where many similar bumps occur throughout the length of the ship, as might be the case if the vessel had been grounded. One way to make such a strongback is illustrated in Fig. 115.

The two sides are cut out of plate and a single hooked piece is made for the end as shown. The bolts can be placed in different holes for different spacing of the longitudinals or stiffeners. For very severe bumps, a hole can be drilled and countersunk as previously explained, giving the steel a chance to work toward the center. These bumps are pushed out and hammered around the edge as explained before. Sometimes one or two men work inside the shell with the jack and strongback while another stays on the ground, outside the ship, to work the pump. (The hose can be led inside through a rivet hole or other hole by means of a brass "shell connection"). When this is done, the following signals are used:

(Hammering on the plate)

1 Blow -- Stop pumping
2 Blows -- Start pumping
3 Blows -- Release pressure

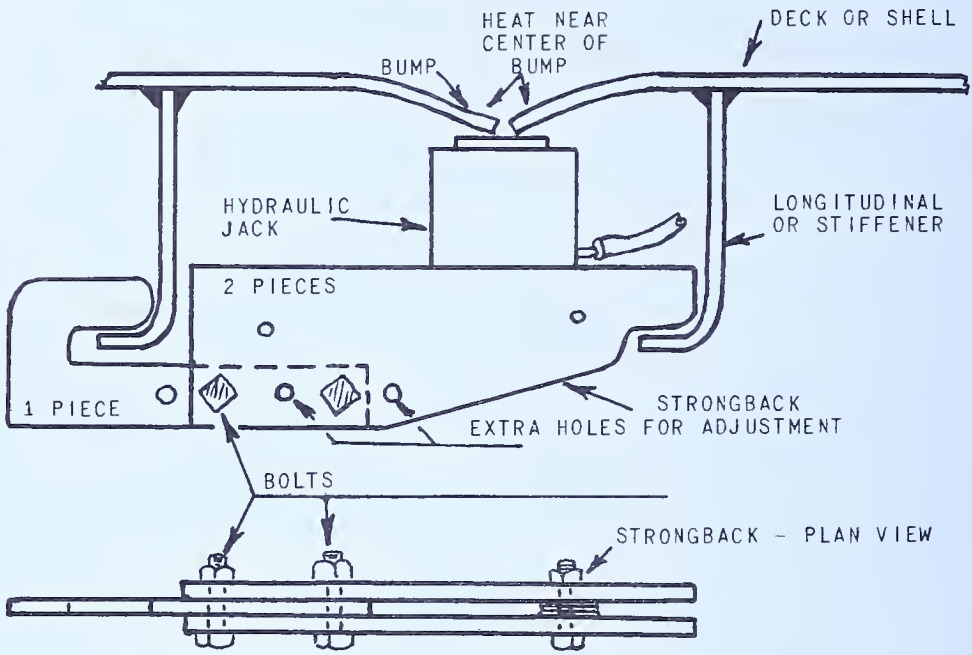


Fig. 115 -- Jacking Out Bumps

These signals eliminate useless climbing in and out of the ship. In almost all cases where bumps need to be faired, a few minutes thought *before starting* work will result in an efficient method of doing the job.

FAIRING BUMPS WITH HEAT

If it is found that a bump cannot be faired by the preceding methods, heat may be applied with a heating torch until the metal is sufficiently soft to flatten out under the force of the jack or bolt. Packing should be used between the jack and the plate to prevent the jack from becoming too hot. The heat should be applied evenly near the center of the bump, as shown in Fig. 115. Alternate heating and mauling generally will flatten the bump to the correct shape. Bumps and bulges caused by local heat concentrations or by weld contraction around the outside of a plate (or around part of a plate) are treated the same way if they are small and sharp, except that heating practically always is required. The heat prevents the bump from "jumping out" on the other side of the plate after it has been forced to flatten out.

CORRECTING DISTORTION BY SHRINKING

Another method of fairing sometimes is used for light bumps and practically always is used in fairing the larger bulges found

after welding the light bulkheads and decks of which deck houses are constructed. This method is called shrinking, and is done in two ways. One way is called straight-line shrinking; the other is known as spot shrinking. Either or both of these are used, depending upon conditions at each job.

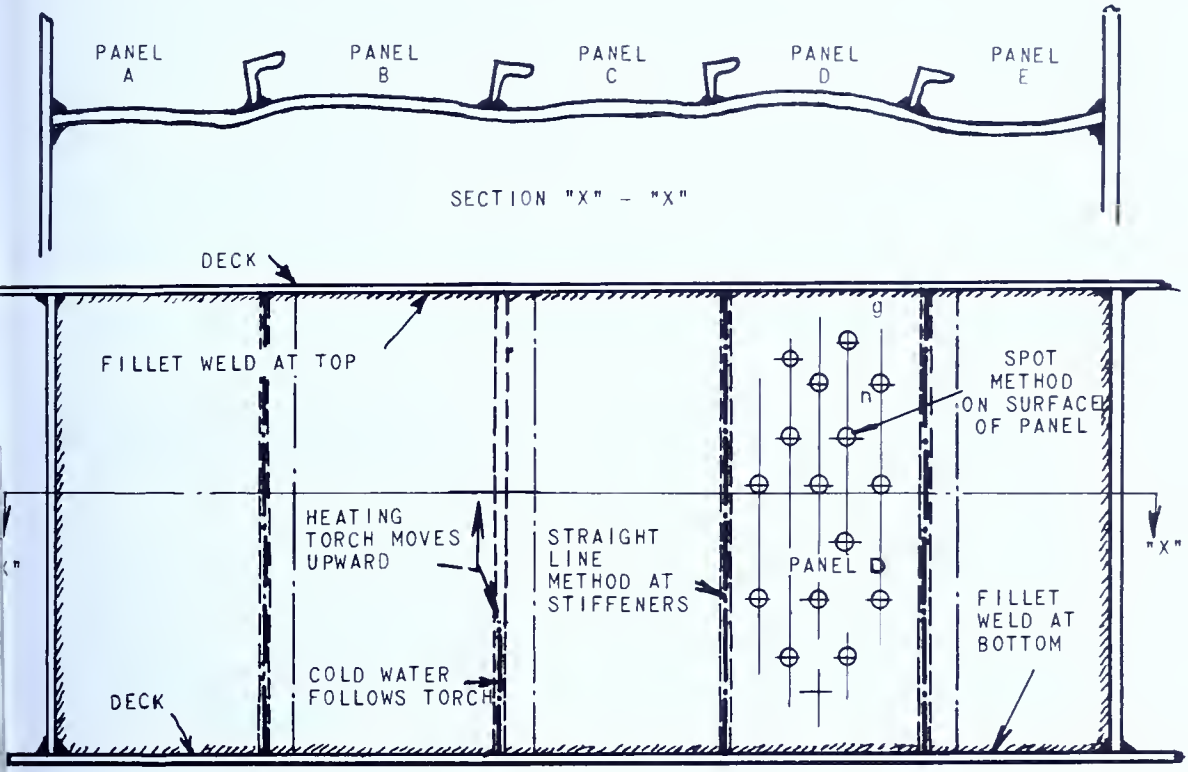


Fig. 116 -- Unfair Bulkhead -- Needs Shrinking

In Fig. 116 is shown a vertical bulkhead with welded inverted angles as stiffeners. This bulkhead has been welded all around and the longitudinal contraction of the top and bottom welds has shortened the edges of the bulkhead, leaving the middle bulged or wrinkled as illustrated.

The fairing man must now shrink this excess metal so that it will straighten, and be as tight as the welded edges.

How to Shrink an Unfair Bulkhead

PROCEDURE:

1. With chalk, mark vertical straight lines opposite bulkhead stiffeners at the most badly distorted panels.
2. With a torch, heat bulkhead on the previously-marked straight lines, starting about 6" from the bottom and working upward to about 6" below the deck. A stream of cold water (or air) must be directed on the heated surface about 2" behind the torch (See Fig. 116).

   The application of water cools the plate suddenly, causing a large contraction which tends to shrink or tighten the plate.

In shrinking the bulkhead illustrated in Fig. 116, heat fir should be applied opposite #3 stiffener, and then opposite stiffener. This may cause sufficient shrinkage to tighten a five panels. If the bulkhead is not tight after "running" t of the stiffeners, the same "straight line" method should used opposite the remaining stiffeners of the bulkhead.

3. If fairness is not satisfactory after "running" the stiffener mark the bulged panels into 3" squares for "spot" shrinkin Horizontal and vertical lines are spaced 3", as shown panel D, Fig. 116.

4. At an intersection of two marked lines, heat a spot to a reddi white color. The torch is then moved to another spot.

5. Immediately after removing the torch from the first heated spo cool the heated spot, as suddenly as possible, with a stream cold water.

Straight Line Method Of Shrinking

Spot Method of Shrinking

The quick cooling of red-hot metal causes local contracti in all directions and serves to shrink the panel, or reduce t excess metal, thus helping to flatten the bulge.

In every case, as few spots as possible are heated to shri the steel. Spots are placed at every second or third inte section, and if part of the bulge remains after going over t whole panel, some of the intermediate spots are used. Often t spot-shrinking of one panel will tighten up one or two pane adjacent to each side.

Markings for shrinking should be omitted near corners a close to decks, as shown in Fig. 117. If this is not don

stresses of contraction will further shorten the welded edge, resulting in a worse bulge, rather than an elimination of the bulge.

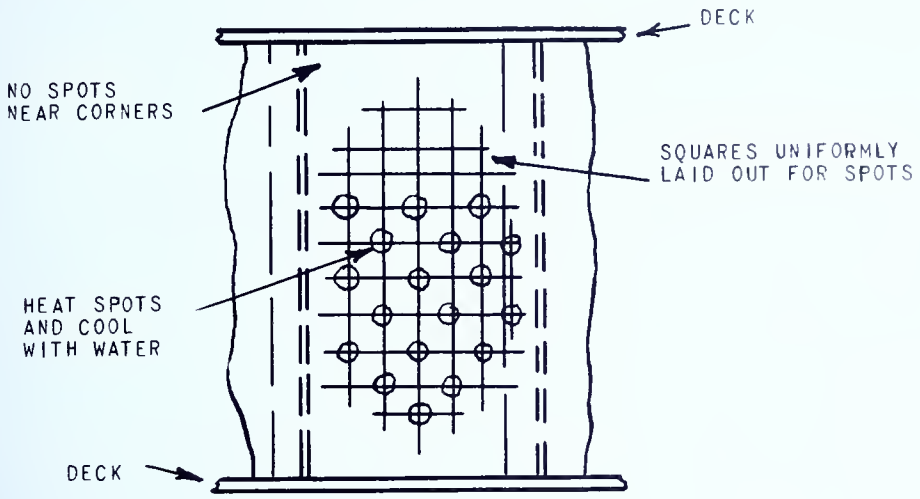


Fig. 117 -- Layout of Panel for Spot Shrinking

SPECIAL TORCH FOR SHRINKING

Figure 118 shows a combination torch and water hose, used in the straight-line method of shrinking. With this rig, one man can do the heating and the cooling at the same time. When two men do this job, they are in each other's way. Also, the torch and the cooling water hose cannot easily be moved at the same speed. This torch is sometimes used in spot-shrinking by turning the water pipe at an angle to the heating tip, and by doing only one operation at a time.

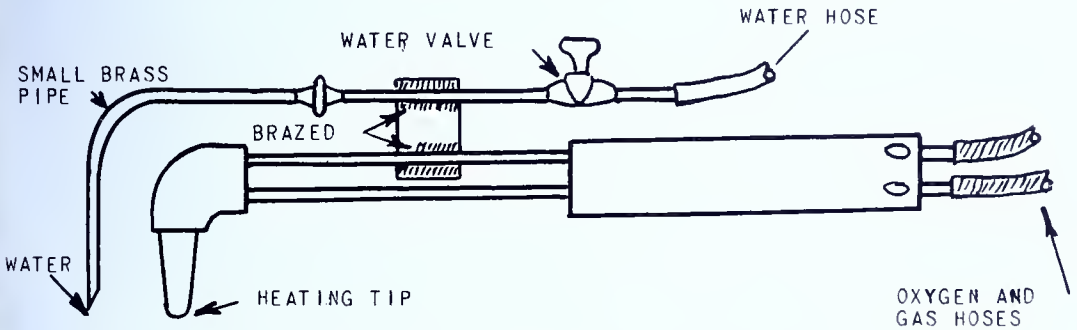


Fig. 118 -- Combination Torch and Water Hose

In some instances, water cannot be used to cool the steel, owing to the possibility of damage to some other part of the ship on which the water might run or fall. An air hose can then be used in the same manner as the water hose. This is not recommended, however, when it is possible to use water.

Questions

1. What are two principal causes of steel distortion?
2. How is distortion minimized when welding plate butts?
3. On which side of a bulkhead should strongbacks be placed?
4. What is "fairing"?
5. What is a "flatter"?
6. What two types of shrinking are used?
7. Why are shrinking spots kept away from corners of panels?
8. Why is air sometimes used for shrinking instead of water?

PART IV

Lines of a Ship

TERMS AND DEFINITIONS PERTAINING TO LINES OF A SHIP

Every shipfitter should be familiar with the technical names denoting ship lines, surfaces, and dimensions. Familiarity with these terms is essential in reading blue prints and in building and installing parts of a ship.

LINES DRAWING -- A plan showing, in three views, the *moulded surface* of the vessel. (See Fig. 125)

MOULDED SURFACE -- The inside surface of the skin, or plating, of a ship. The moulded surface has no thickness, and is fair and smooth.

Actually, when the ship has been built, the thickness of the plating will extend outside of the moulded surface. "Outside" strakes of plating do not touch the moulded surface if they have a liner against the shell frame. The *heel* of each shell frame is in this moulded surface (unless joggled). It should be remembered that this moulded surface is not an actual part of the ship. It is almost exactly the shape which a thin piece of sheet rubber would take if stretched tightly over the shell frames and main deck beams with no plating in place (See Fig. 119).

BASE LINE -- A straight horizontal line at or near the bottom of the *moulded surface* from which vertical heights are measured. Usually, the base line is the very lowest part of the moulded surface. In Fig. 120 is shown an exception.

WATERLINE -- The intersection of the moulded surface with a horizontal plane at a given height above the base line. The six foot water lineis exactly six feet higher than the base line.

These intersections are shown in the half breadth plan in the lines drawing. They should not be confused with the "load line" marked on the outside of a ship when built.

Shipfitters use a waterline merely as a height above the base line and in this sense waterlines are marked on bulkheads, frames, and other members, for the purpose of properly setting and aligning the structure.

CENTER LINE -- A straight line running from bow to stern, midway between the sides of the ship. All transverse horizontal dimensions are taken from the center line. The center line as applied to a transverse bulkhead is a vertical line in the middle of the ship.

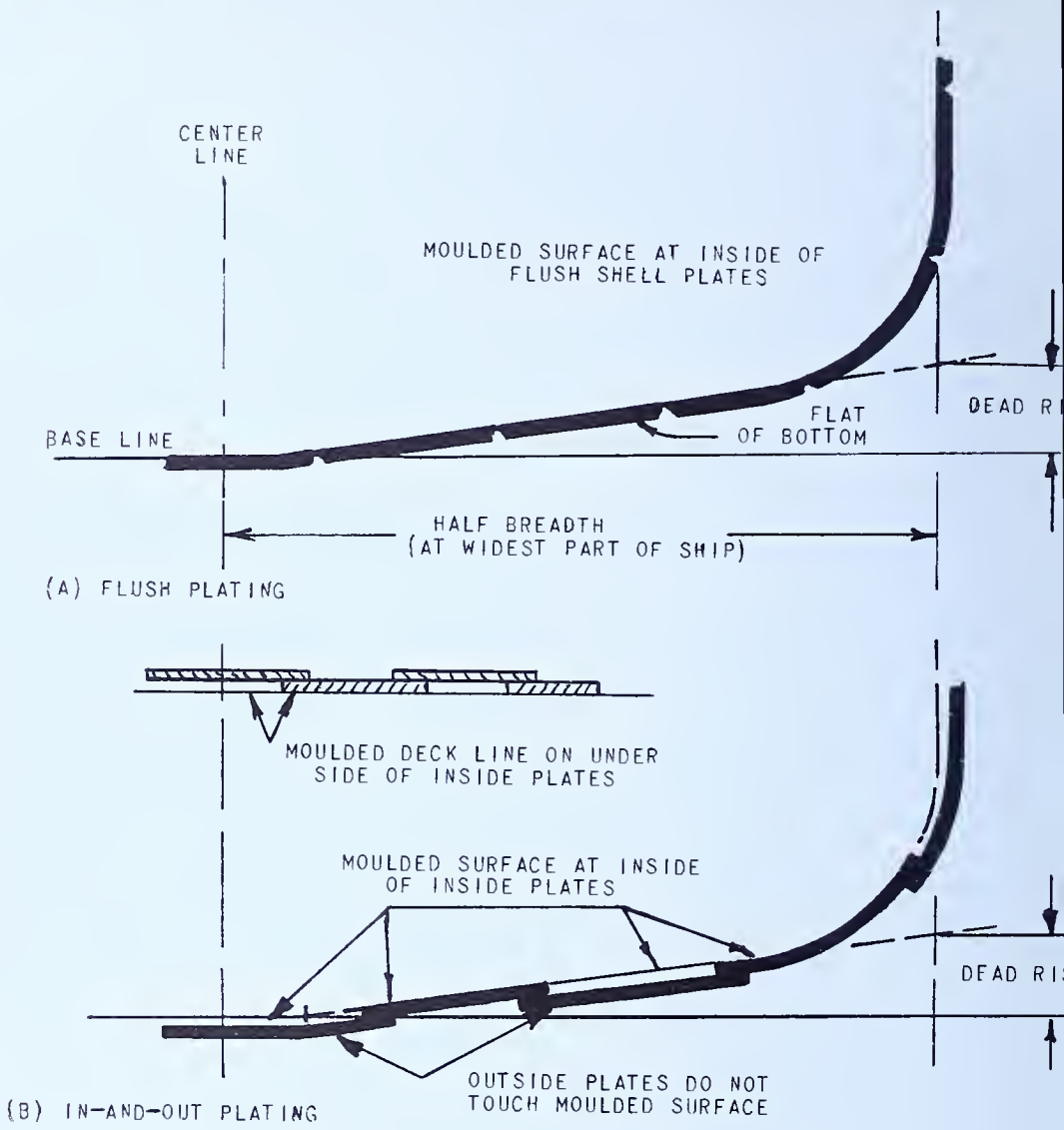

CENTER LINE
MOULDED SURFACE AT INSIDE OF FLUSH SHELL PLATES
BASE LINE
FLAT OF BOTTOM
HALF BREADTH (AT WIDEST PART OF SHIP)
(A) FLUSH PLATING
MOULDED DECK LINE ON UNDER SIDE OF INSIDE PLATES
MOULDED SURFACE AT INSIDE OF INSIDE PLATES
OUTSIDE PLATES DO NOT TOUCH MOULDED SURFACE
(B) IN-AND-OUT PLATING

Fig. 119 -- Moulded Surface

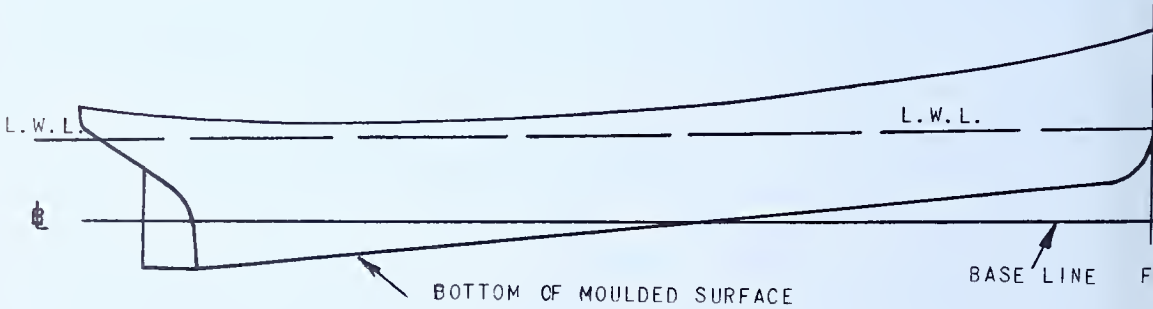
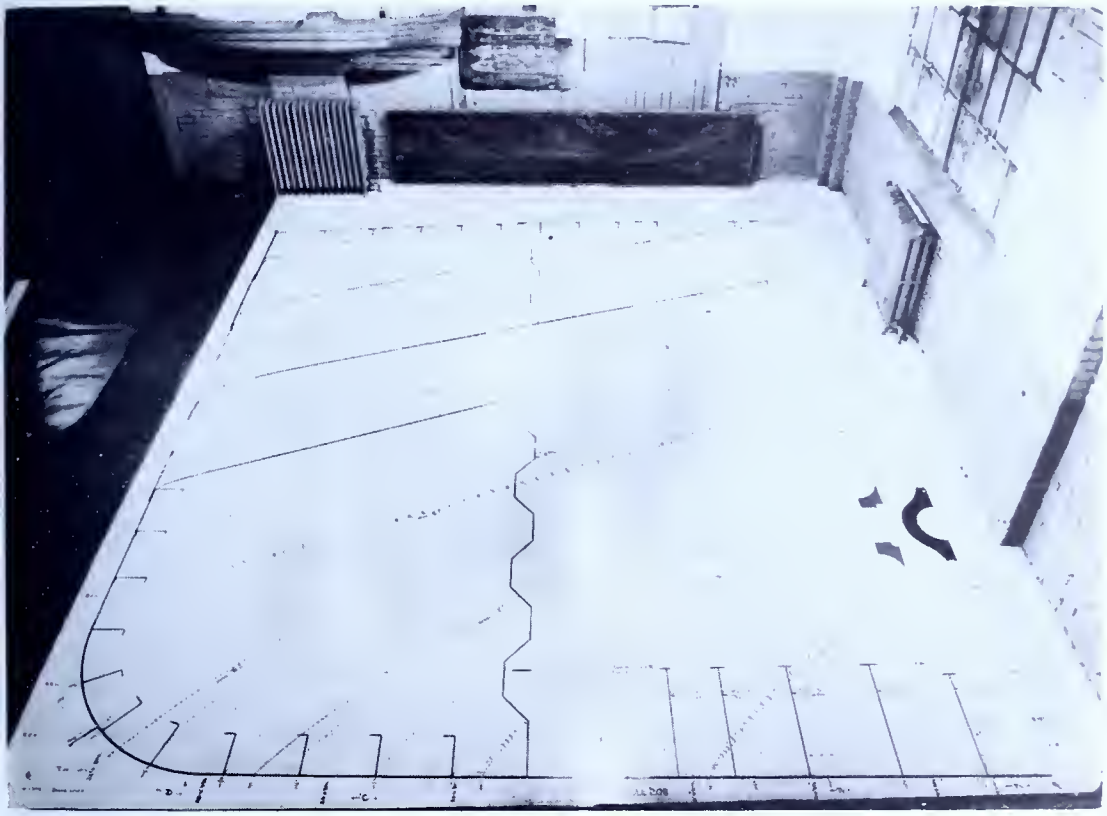


Fig. 120 -- Unusual Base Line Location

BUTTOCK -- The intersection of the moulded surface with a vertical plane at a given distance from the centerline of the ship. Buttocks are shown in the profile in the lines drawing.



Body Plan Developed by Members of the Shipfitting Class

Shipfitters use a buttock merely as a distance from the centerline. Thus, they have buttocks marked on bulkheads, decks, foundations, etc., for setting and alignment. The buttocks and the waterlines which are marked on the steel members for regulating and setting are usually of some dimension expressed in even feet. That is, they would mark the 10'-0" W.L. (waterline) and the 24'-0" Btk. (buttock) rather than a 10'-7" W.L. or a 23'-6" Btk.

FRAME LINE -- The intersection of the moulded surface with a vertical plane perpendicular to the centerline (transverse plane). Frame lines are shown in the body plan of the lines drawing. They get their name from the fact that shell "frames" or ribs usually are made to this shape and installed transversely in the ship. The lines drawing consists of three views; a half-breadth plan, a profile view, and a body plan (See Fig. 125). These views each show only one side of the ship (usually, the port side), because all dimensions for the starboard are equal and to the opposite "hand"; that is, the ship is symmetrical about the center line.

PROFILE -- A view looking at the moulded lines from starboard t port. The waterlines and the frame lines are straight when ob served from this direction. The deck line, or "sheer" curv shows up clearly in the profile, which for this reason i sometimes called the sheer plan.

BODY PLAN -- A view showing the shapes of the frame lines. Th body plan is made in two parts. The right-hand part is a vie looking directly aft at the for'd port side of moulded surface while the left-hand part is a view looking directly forward a the after half of the port side. This arrangement prevents th frame lines at the after end from obliterating or fouling th frame lines at the forward end. This view shows buttocks an waterlines straight, while the frame lines appear in their tru shape.

HALF-BREADTH or WATERLINE PLAN -- A view looking down on the mould ed surface. Here the frame lines and buttocks appear straight while the waterlines show their true shape. To save space, onl the port side is shown.

LOAD WATERLINE (L.W.L.) -- The waterline at which the ship wil float when loaded to its designed draft.

FORWARD PERPENDICULAR (F.P.) -- A vertical line at the point wher the load waterline crosses the foremost part of the moulde surface.

AFTER PERPENDICULAR (A.P.) -- A vertical line usually at the afte end of the rudder post. If there is no rudder post, it usuall is taken at the center of the rudder stock.

LENGTH BETWEEN PERPENDICULARS (L.B.P.) -- The distance from th forward perpendicular to the after perpendicular. To the de signers, this length is very important, since upon it largel depends the amount of power needed to drive the ship.

LENGTH OVER ALL (L.O.A.) -- The total length of the ship from on end to the other, including bow and stern overhangs.

MIDSHIP SECTION -- A transverse section exactly half way betwee the F.P. and the A.P. Almost invariably, this is the widest par of the ship.

PARALLEL MIDDLE BODY -- The straight part at the center of th ship where the water lines and buttocks have no curvature; tha is, where all the fore and aft lines are parallel.

DEADRISE -- The rise of bottom. It is the difference in heigh between the base line and the point where the straight lin through the bottom flat surface intersects the vertical lin through the side of the moulded surface at its widest point (See A and B in Fig. 119; also, Fig. 121)

BEAM -- The width of the ship (moulded surface) at the wides point. (See Fig. 121)

DEPTH -- The height of the ship at the midship section from th base line to the moulded line of the deck at side (underneath)

DRAFT (Moulded) -- The height from the base line to the load water line.

FREEBOARD (Moulded) -- The difference between the moulded depth and the moulded draft. (It is the height of the side of the vessel which is above the water when she floats at her load water line).

CAMBER -- The curvature of the deck transversely. It is measured by the difference in height between the deck at center and the deck at side.

TUMBLE HOME -- The amount the top of the side shell slopes back toward the centerline between the point of widest breadth and the deck at side (see Fig. 121).

SHEER -- The curvature of the deck at side as shown in the profile. The *amount of sheer forward* is the difference in height between the deck line (at side) amidships and the deck line at the forward end (see Fig. 122).

The amount of sheer aft is the difference in height between the deck (at side) amidships and the deck at the after end. The line of the deck at center, in the profile, is higher than the line of the deck at side, owing to the camber, or transverse curvature of the deck.

In Fig. 122 is illustrated the difference between the deck at the side and the deck at the center, owing to camber. The camber curve, as usually designed, is a circle of very large radius, but sometimes it is made as a series of straight lines, as in Fig. 123. The camber curve is the moulded line of the deck.

Instructor and Apprentice Boys Working on Body Plan in Shipfitting School

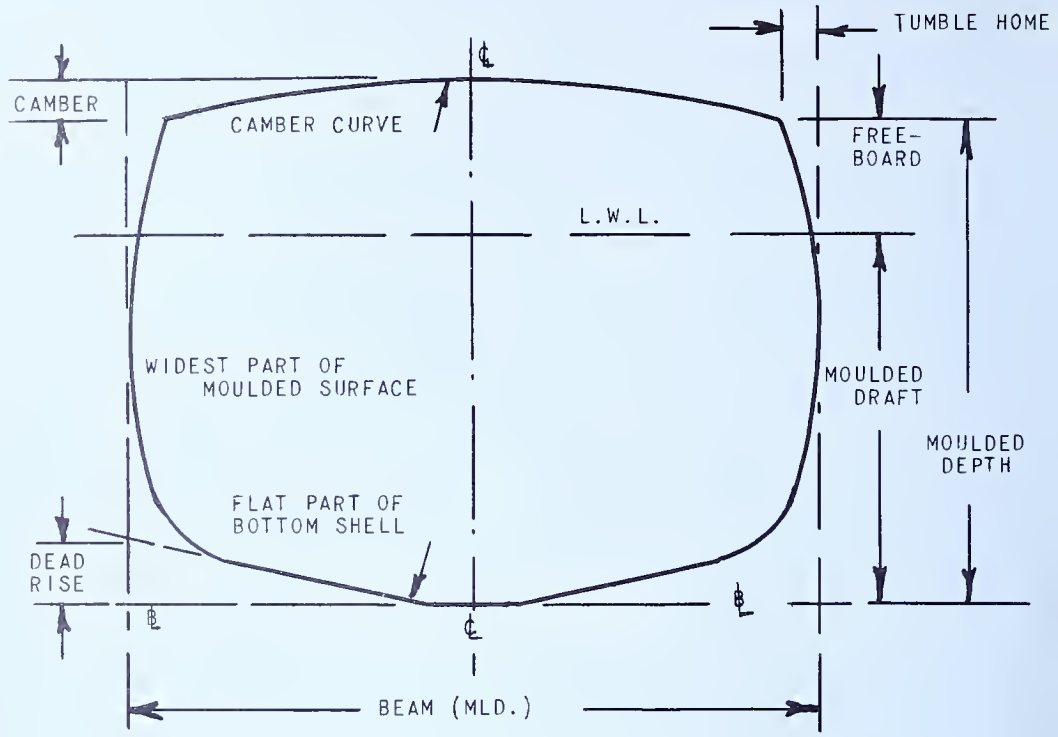


Fig. 121 -- Moulded Dimensions at Midship Section

Fig. 122 -- Sheer Curve

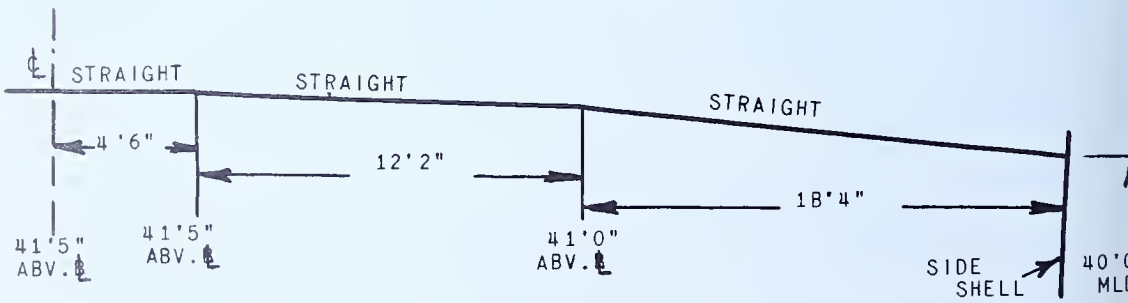


Fig. 123 -- Camber Curve - (Composed of Straight Lines)

MIDSHIP SECTION AND OFFSETS

The midship section of a ship, as stated before, is a transverse section taken halfway between the forward perpendicular and after perpendicular. Figure 124 shows the midship section of a type of oil tanker, giving the outline of the moulded surface at this section and also the spacing of the shell longitudinals and the longitudinal stiffeners.

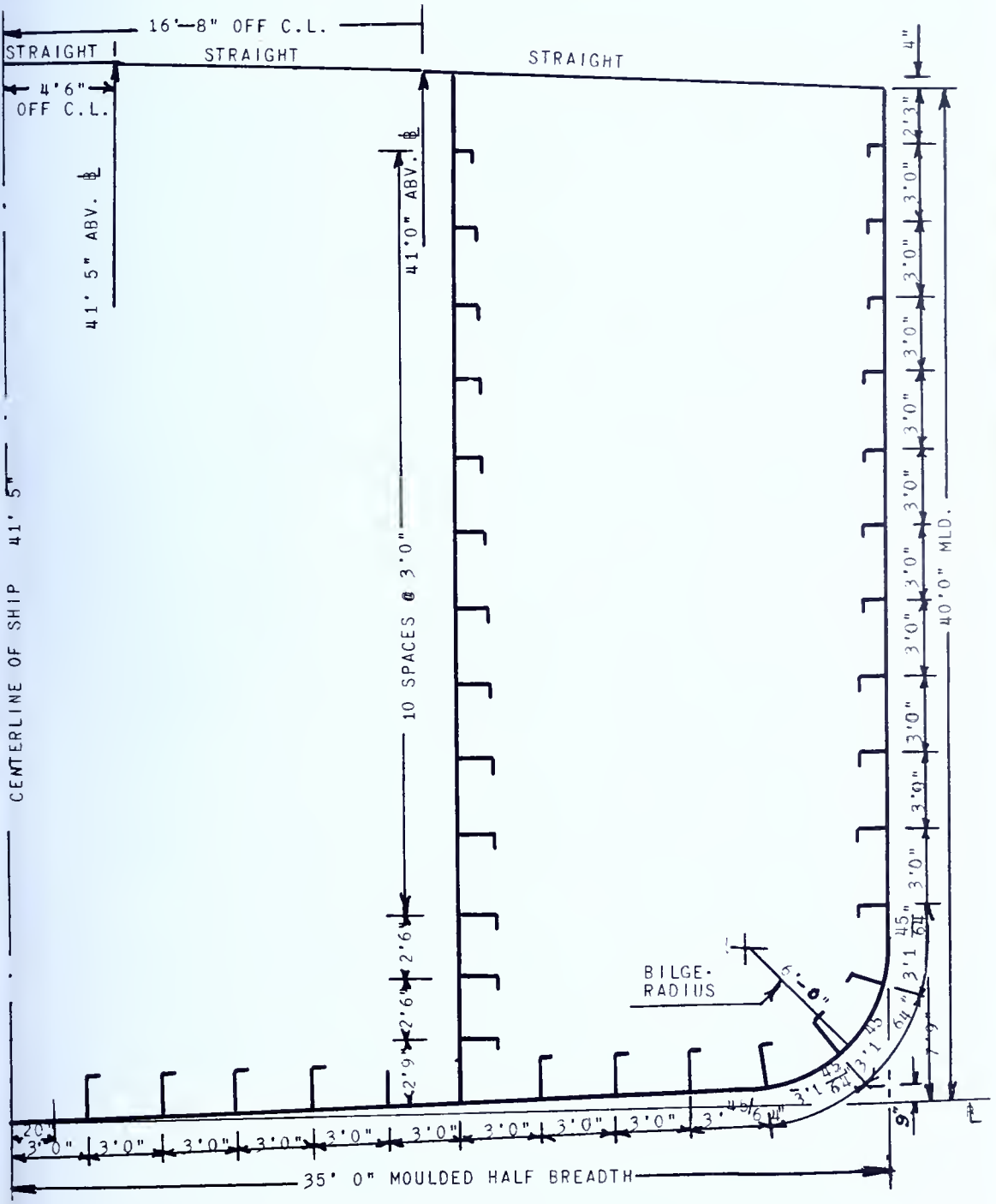


Fig. 124 -- Midship Section of an Oil Tanker

The camber of the deck is shown, as well as the deadrise an the bilge radius. This shape and spacing applies throughout th parallel middle body of the vessel (in this example, from fram 26 to frame 44).

As illustrated, the shell longitudinals are three feet apar except for one space at the top of the side shell and four space in the bilge. The longitudinal bulkhead stiffeners are three fee apart except for three spaces at the bottom. The deadrise is nin inches. The moulded beam is seventy feet. The moulded depth i forty feet. The bilge radius is six feet. The camber of the dec is 1'-5" in straight lines. There is no tumble home.

The stiffeners (longitudinals) heel inboard on the bottom shel and upward on the side shell and longitudinal bulkhead. In Fig 125 are given the midship section offsets for this tanker. Offset are measurements of distance from the base line or from the center- line to any point in the moulded surface. Half-breadths are measured transversely from the centerline. Heights are measure vertically from the base line. From the table of half breadths, we see that at frame 26, the 8 foot waterline is exactly 35 feet from the centerline. The 2 foot waterline is only 32' 9-3/4" fro the centerline at this frame. (The offset 32-9-6 means 32 feet - 9 inches - 6 eights of an inch, or 32 feet 9-3/4").

From the table of heights, we see that at frame 44 the four foot buttock is only 5/8 of an inch above the base line, and the 24 foot buttock is 6-1/8 inches above the base line. These midship section offsets apply from frame 26 to frame 44, which is the extent of the parallel middle body.

Table X -- Midship Section Offsets

HALF-BREADTHS ON WATERLINES AND DECKS					
Frame	2'W.L.	4'W.L.	8'W.L.	12'W.L.	16'W.L.
26-44	32-9-6	34-4-5½	35-0-0	35-0-0	35-0-0
Frame	20'W.L.	24'W.L.	28'W.L.	32'W.L.	36'W.L.
26-44	35-0-0	35-0-0	35-0-0	35-0-0	35-0-0

HEIGHT ON BUTTOCKS & DECKS					
Frame	4'Butt	8'Butt	12'Butt	16'Butt	20'Butt
26-44	0-0-5	0-1-6	0-2-6½	0-3-7½	0-5-0
Frame	24'Butt	32'Butt	UPDK-SIDE	UPDK C. Line	
26-44	0-6-1	1-5-3	40-0-0	41-5-0	

Table X shows the offsets for the tugboat whose lines ar illustrated in Fig. 125. At each frame station are tabulated th half-breadths for the 2-foot, 4-foot, 6-foot, 8-foot, 10-foot an 12-foot waterlines, and also for the deck at side. The heights o the 3' 6" and 7' 0" buttocks are also given for each frame statio from #0 to #10.

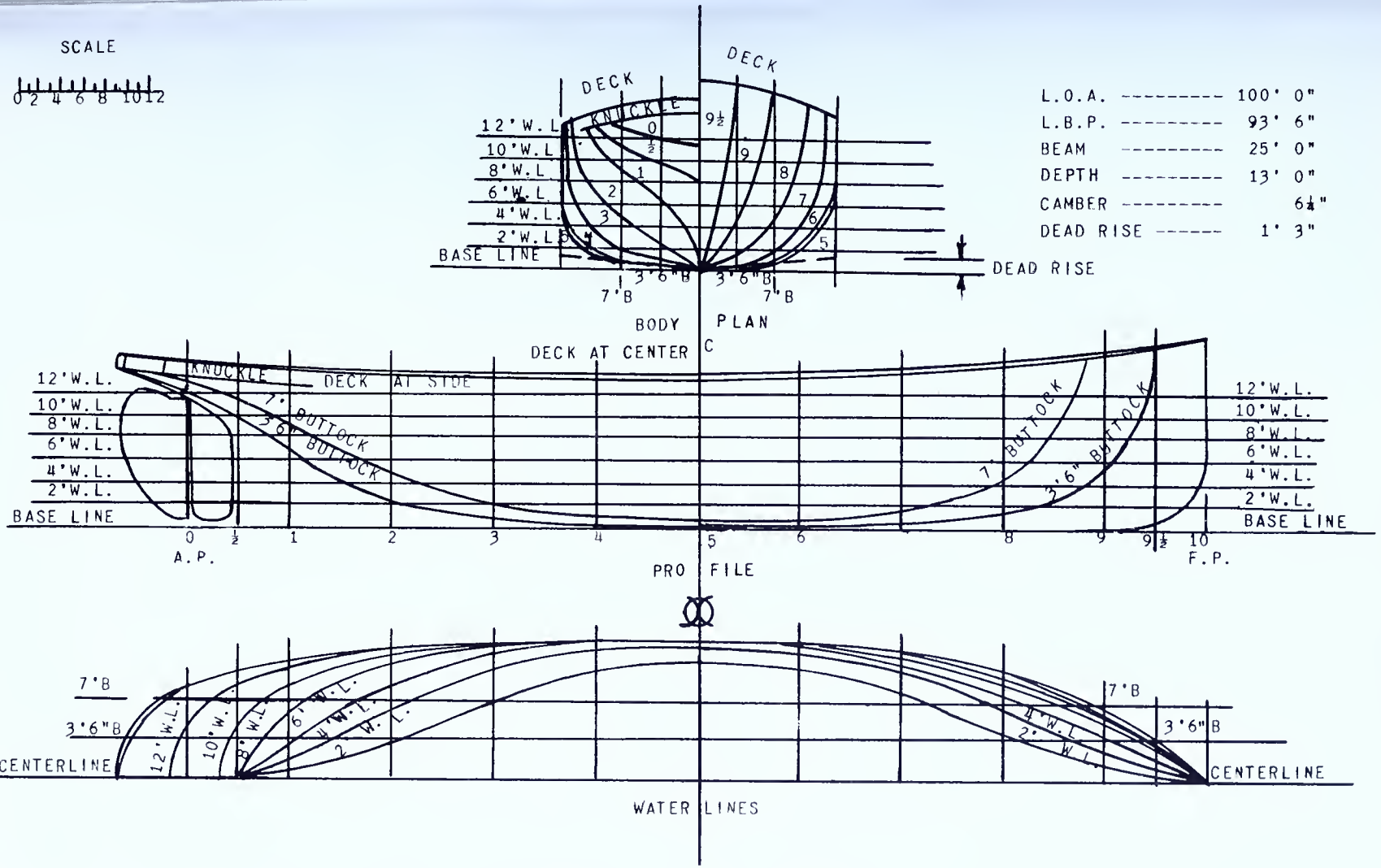


Fig. 125 -- "Lines Drawing"

Table XI -- Offsets for Tugboat

HALF-BREADTHS							
Station	2' W.L.	4' W.L.	6' W.L.	8' W.L.	10'W.L.	12'W.L.	DK.at sid
0						4- 6-0	7-10-6
½					4- 7-7	8- 1-1	9- 4-4
1	0- 6-2	1- 3-3	2- 9-5	5- 6-4	8- 2-6	0- 9-3	10- 4-3
2	3- 1-0	6- 0-4	8- 6-0	10- 2-7	10-11-0	11- 5-5	11- 8-0
3	6-10-5	9-10-1	11-2-7	11- 8-7	11-11-4	12- 2-1	12- 3-2
4	9- 8-0	11- 7-3	12- 4-0	12- 5-7	12- 6-0	12- 6-0	12- 6-0
5	10- 6-0	12- 0-2	12- 5-7	12- 6-0	12- 6-0	12- 6-0	12- 6-0
6	9-11-4	11- 6-5	12- 2-2	12- 5-7	12- 6-0	12- 6-0	12- 6-0
7	7- 8-0	9- 7-7	10- 4-7	11- 2-0	11- 5-4	11- 7-0	11- 8-0
8	4- 3-5	6- 5-4	7- 9-7	8- 7-5	9- 2-4	9- 7-1	9-10-6
9	1- 7-1	2-10-1	3-10-3	4- 7-7	5- 3-2	5- 9-3	6- 4-2
9½	0- 8-2	1- 2-7	1-10-0	2- 3-6	2- 8-1	3- 0-6	3- 5-7

HEIGHTS			
Station	3'-6"B	7'-0"B	DK.at side
0	11- 9-4	12-11-0	14- 5-0
½	9- 7-1	11- 1-4	14- 2-2
1	6- 7-5	8-11-4	13-10-0
2	2- 3-4	4- 9-1	13- 3-7
3	0- 9-5	2- 1-3	13- 0-3
4	0- 4-1	0- 8-7	13- 0-0
5	0- 3-7	0- 8-3	13- 2-3
6	0- 3-7	0- 8-6	13- 7-7
7	0- 6-0	1- 7-1	14- 4-5
8	1- 5-7	4- 5-2	15- 3-0
9	5- 4-7		16- 2-7
9½			16- 9-0
10			17- 3-4

The table of offsets for an ordinary cargo ship or tanker consists of many pages and usually includes the following items: profile, frame spacing, midship section, camber curves, stem and stern profile, rail profile, detail of frames at bossing, half-breaths, heights, and sight edges.

Sight edges are the longitudinal edges of shell (or deck) plates which are visable on the outside of the hull. It should be remembered that in practically all ships, the frame spacing is different in different locations, and before taking any measurements a drawing should be consulted.

Questions

1. What is a midship section?
2. What is meant by "bilge radius"?

3. What are "offsets"?
4. How are offsets expressed?
5. What items usually are found in a table of offsets?
6. What are "waterlines"? Buttocks?

LOCATING FRAME LINE AT BULKHEAD

When it becomes necessary to set a transverse bulkhead or other member by means of a frame line marked on the adjacent members, the frame line must first be determined at the bulkhead itself. (See Fig. 126.) In other words, it must be found out whether the face side (smooth side) of the bulkhead is to be directly on the moulded line, or whether the stiffener side of the plating is to be on the moulded line. This information must be obtained from the drawings. No specific rule will cover all cases, and the frame line is sometimes on the forward side of the bulkhead, and sometimes on the after side. In case of a discrepancy between two drawings showing the same member (for instance if the shell drawing shows the bulkhead plating aft of the frame line, while the bulkhead drawing shows the plating thickness *forward* of the frame line) the *shell plan* shall be assumed correct for the purpose of setting the bulkhead.

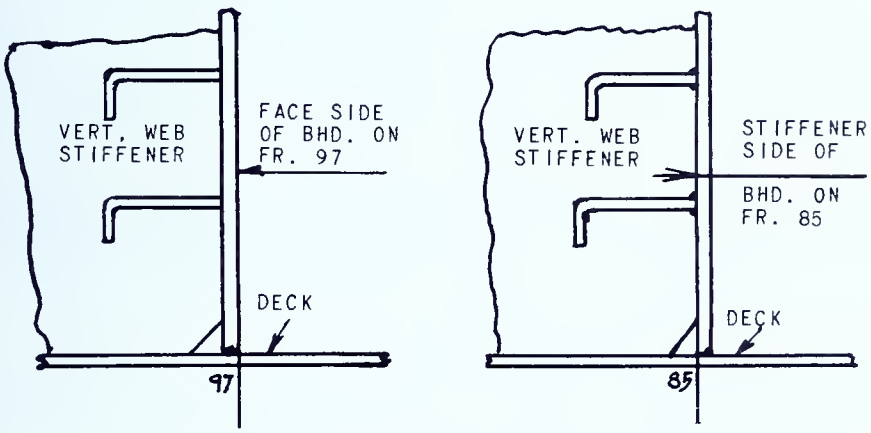


Fig. 126 — Examples of Frame Line Location for Transverse Bulkhead

Questions

1. How is the frame line at a transverse bulkhead determined?
2. In the event of a disagreement in drawings, which drawing should the shipfitter use in determining a frame line?

CORRUGATED BULKHEADS

In setting the more recently adopted type of corrugated bulkheads, as in Fig. 127, the drawing must be consulted for location of frame line. Here the moulded line may be on either the face

side or the stiffener side of the bulkhead, *at the extreme width of the web bulkhead stiffeners.*

Fig 127 -- Frame Line Location at Corrugated Bulkheads

In this type of corrugated bulkhead, the depth of the corrugations varies at different heights on the bulkhead. The deeper corrugations at the bottom supply the increased bulkhead stiffness which is required, owing to greater pressure of water (or other liquid) in the lower part of the tank.

SCRIBING AT CORRUGATED BULKHEAD

When it is necessary to scribe a large bracket or other plate to fit in the corrugations of a bulkhead, the following precautions must be taken to assure a neat fit.

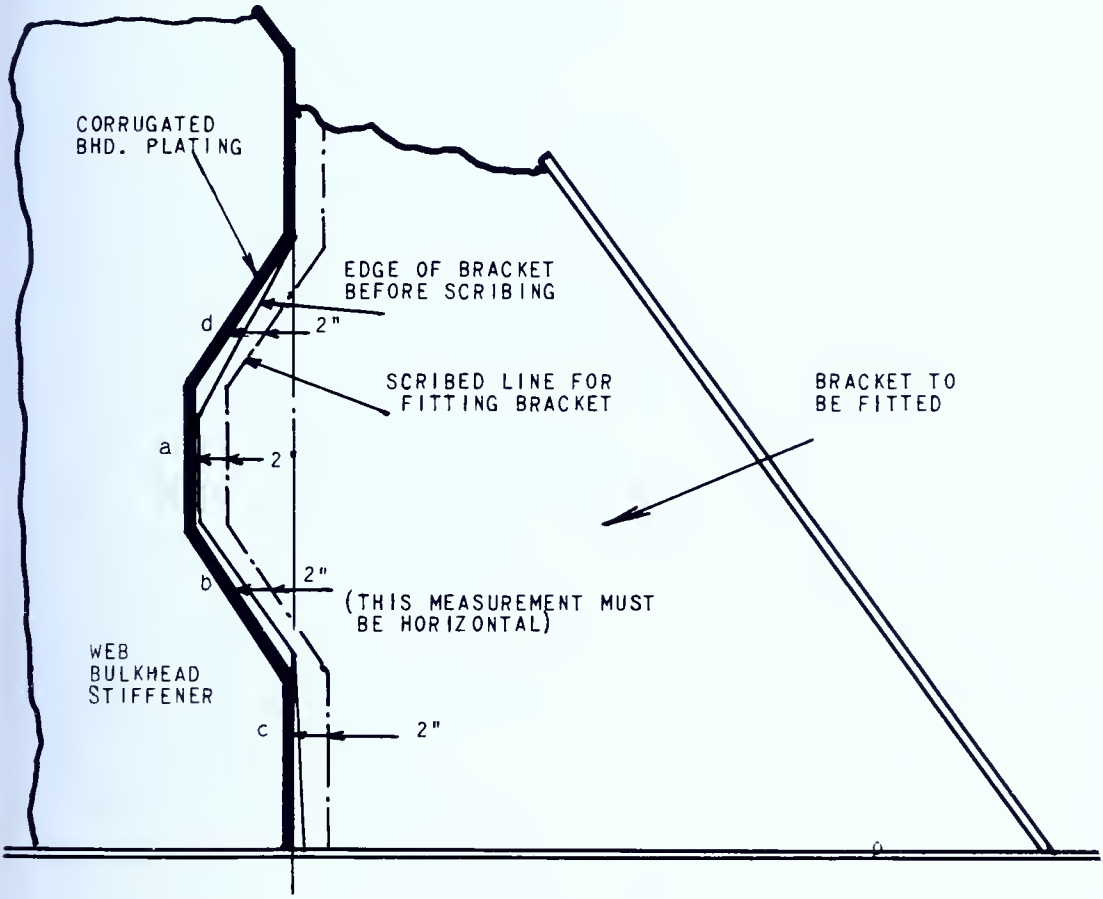


Fig 128 -- Scribing a Plate to fit Bulkhead Corrugations

The bracket shown in Fig. 128 must be scribed off to move 2" to the left. If there were no corrugations, this would be a simple matter of marking a vertical line on the bracket with a 2" spacer to give the proper cut. This line would be similar to that shown at "a" and at "c" in Fig. 128. However, the sloping sides of the corrugations, as at "b" and "d" cannot be marked off with the same 2" spacer, because the opening thus burned out would be too large. The measurements for scribing *at the sloping surfaces* (that is at "b" and "d") must therefore be taken in a horizontal direction as shown. The principle here is the same as that of scribing a foundation to set against a sloping surface, as explained in a later sheet. (See Fig. 167, Page 153)

PART V

Leveling, Plumbing, and Squaring

DECLIVITY OF SHIPWAYS

Ships usually are built on sloping ground or on ways which are built up to form a sloping foundation, so that the ship's own weight will cause it to slide into the water when it is completed and released at launching time. The ship's bottom is supported by blocks and shores which later are removed to make room for the greased ways or skids.

The slope of the shipway (that is of the sliding surface) is called the *declivity*. It is given in *inches per horizontal foot*, as shown in Fig. 129.

The rate of rise of the line "ab" is such that for every foot along the level "bc" the vertical rise of the sloping line is 5/8", or "ac". Declivity of shipways varies in different yards. In the Sun yard, shipways #1, #2, #8, and #9-#20 inclusive, have a declivity of 5/8" per foot. Shipways #3, #4, #5, #6, and #7 have a declivity of 11/16" per foot.

Usually the bottom of the ship's keel is parallel to the base line, (although this is not always true). The tops of the keel blocks when set up must all be on a line which has the same declivity as the ways themselves. The base line and all of the water-

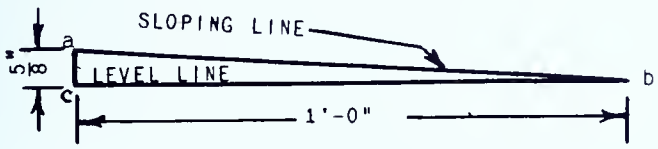


Fig. 129 -- Declivity of Shipways

lines will then be parallel to the line of the keel blocks, and will have this same declivity, while the frame lines of the ship will be at right angles to the base line. These conditions are illustrated in Fig. 130, which also shows how levels, declivity boards, and plumb lines are used to keep bulkheads, masts, etc., correctly aligned when erecting and regulating the ship.

USE OF DECLIVITY BOARD

A declivity board is an accurately planed board whose two opposite edges are not parallel, but form an angle equal to the angle of the slope of the shipway. When the top edge of the board is made horizontal by means of an ordinary carpenter's level, as shown at "a" in Fig. 130, the bottom edge of the board will slope down at the proper rate and can be used to test the declivity of waterlines, base line, etc., in a fore and aft direction. No declivity board is used when testing waterlines transversely, since there is no slope in that direction.

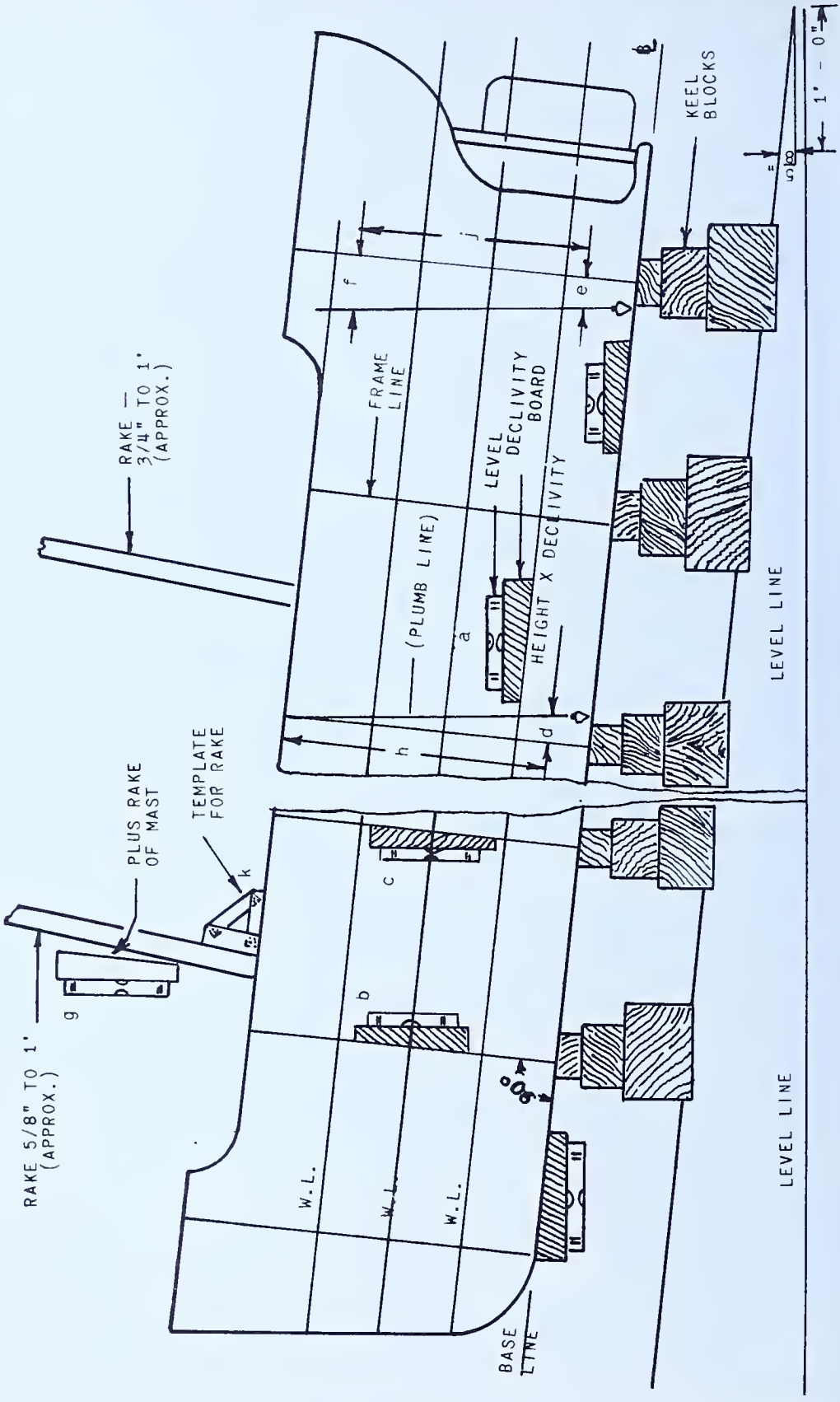
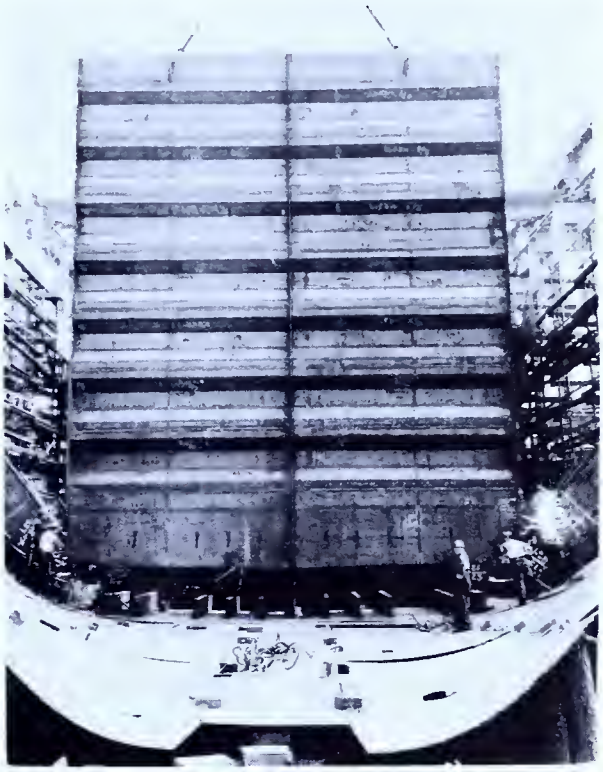


Fig. 130 -- Leveling and Plumbing of Ship During Construction

Frame lines and transverse bulkheads are perpendicular to the base line, permitting declivity to be tried as shown at "b" in Fig. 130, using the level in its vertical position. By turning the declivity board end for end, the forward side of the bulkhead may be tried as shown at "c".

Since a ship on the ways has declivity in the longitudinal (fore and aft) direction only, it is imperative that the level be held parallel to the centerline of the ship when used with a declivity board. When used for transverse leveling, no declivity board is used and the level must then be held at right angles to the centerline; that is, parallel to the frame lines.



Center Section of Corrugated Transverse Bulkhead Being Erected

Let us suppose that the foundations in Fig. 131 are to be set so that they will be level when the ship is floating on an even keel. The sides of one foundation are parallel to the centerline of the ship, while the sides of the other are not. However,

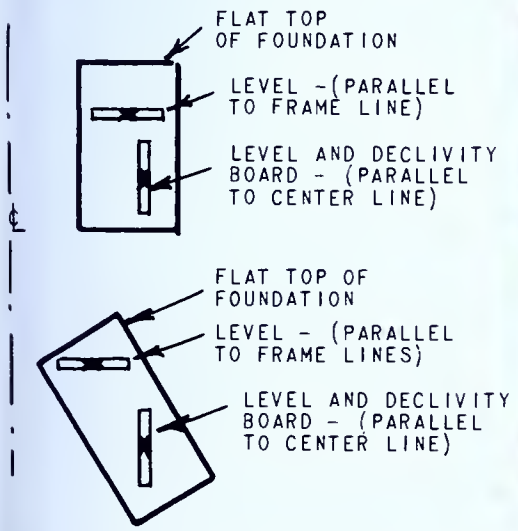

FLAT TOP OF FOUNDATION
LEVEL - (PARALLEL TO FRAME LINE)
LEVEL AND DECLIVITY BOARD - (PARALLEL TO CENTER LINE)
FLAT TOP OF FOUNDATION
LEVEL - (PARALLEL TO FRAME LINES)
LEVEL AND DECLIVITY BOARD - (PARALLEL TO CENTER LINE)

Fig. 131 -- Placing of Level and Declivity Board

Leveling and Setting on Auxiliary Foundation

in order for the top surface of each to be level, the level and declivity board *must* be applied as shown in both cases.

It can readily be seen that a level turned around at some oblique angle on a truly level surface (that is, level with respect to the base line) will no longer be level. If it is parallel to the centerline, it needs a declivity board under it, and if at right angles to the centerline, it would fit without a board. At any intermediate position it would not fit either way. Therefore, a foundation set by improper placing of the level would not be in its correct position.

USE OF PLUMB BOB AND LINE

Another and more accurate method of testing the declivity of a transverse bulkhead is by means of a plumb line and bob as at "d" in Fig. 130. The plumb line can be hung at the after side of the bulkhead (near a vertical stiffener if possible) and the vertical height "h" measured from the top to where the measurement "d" is taken. This height (in feet) multiplied by the declivity (in inches per foot) gives the required dimension "d" in inches. This dimension is measured from the bulkhead to the plumb line and at *right angles to the bulkhead*. If "d" when measured is too large, the bulkhead must be rocked forward (taking for granted that the bulkhead is set properly at the bottom).

If for any reason it is not convenient to hang the plumb line on the after side of the bulkhead, it can be arranged as shown at "e" and "f" in Fig. 130. The plumb line is hung forward of the bulkhead from any available support, and the distances "f" and "e" are measured at two points whose difference in height is the distance "j". Then if the bulkhead is plumbed properly, "f-e" (in inches) is equal to "j" (in feet) multiplied by the declivity.

Figure 132 shows a plumb bob hanging in such a way as to show whether a transverse bulkhead is leaning to port or starboard. The plumb line is hung at any given distance from the centerline at the top of the bulkhead. A line "ab" is marked on the tank top at the same distance from the centerline of the ship. If the bulkhead is plumb transversely, the plumb bob will hang exactly over this line "ab", otherwise the bulkhead must be rocked to one side or the other.

RAKE OF MASTS

The masts of a ship almost always are slanted or "raked" aft from the perpendicular to the base line. The after mast would be raked more than the forward mast, and the stack still more.

If, as sometimes happens, the mast is erected before launching, it can be set to the required slant with a level and declivity board, as at "g" in Fig. 130. The bottom of the declivity board is tight against the mast while the top is held forward a distance equal to the length of the board times the rake. This also can be accomplished by making a special template whose sides slope together at an angle corresponding to the *declivity* of the shipway

lus the rake of the mast. Usually, owing to need for crane service, the masts are not erected until after the ship is launched.

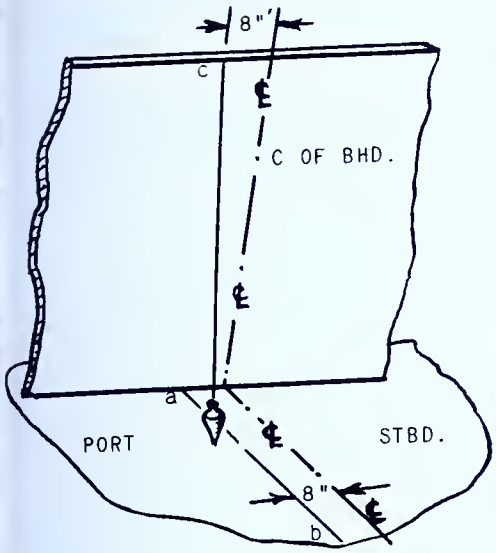
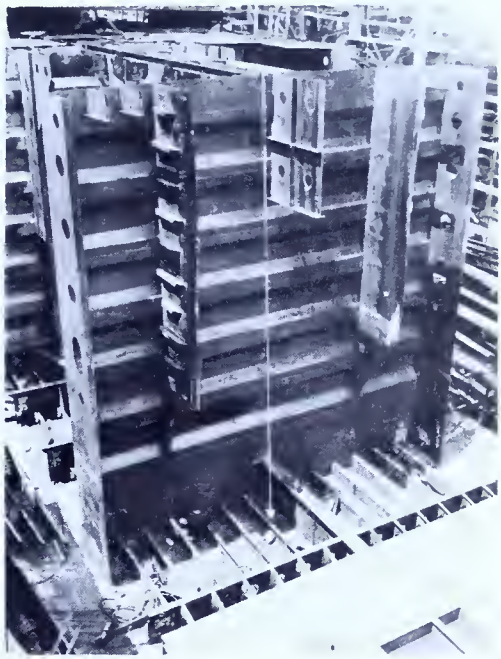


Fig. 132 -- Plumbing a Bulkhead Transversely



Center Section of Transverse Bulkhead in Place. (Note Plumb Bob.)

ALIGNING MEMBERS AFTER LAUNCHING

When the ship is in the water or on dry dock, levels and plumb lines cannot be used, because the ship changes position. She is constantly moving because of wind, waves, and the addition of weight (of engines or other steel work).

Masts are tried for proper rake (when erected in the wet basin) by means of measurements or by means of a template made to allow for the sheer of the deck and applied as at "k" in Fig. 130. This template should be lifted before launching, or made in the mold loft.

Erecting and Checking Perpendiculars

When a ship has been properly regulated, the frame lines are all at right angles to the centerline, and should be checked before being riveted or welded. The most common method of checking two lines for being square is shown in Fig. 133.

At (A) is shown a triangle whose sides are three inches, four inches, and five inches. The angle between the three-inch and four-inch sides is a right angle. It can be proved by geometry that every triangle whose sides are in the ratio of 3, 4, and 5 will have a right angle between the two short sides. The sides could be 3, 4, and 5 feet - 30, 40 and 50 feet - 15, 20 and 25 feet, or any number of feet or inches provided they are in the ratio of 3, 4, and 5.

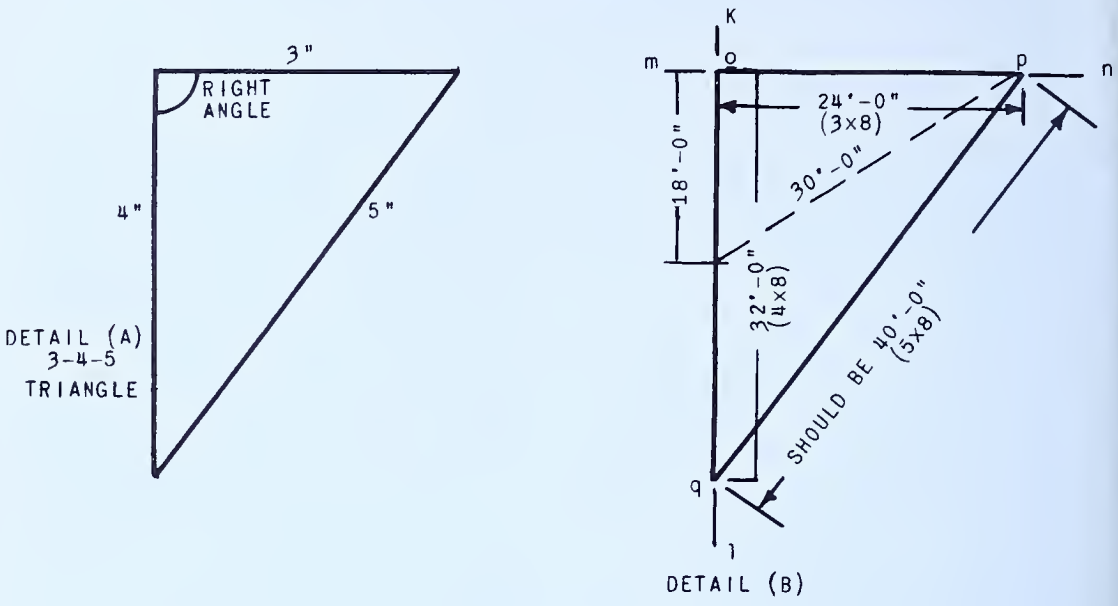


Fig. 133 -- Checking Perpendiculars by Using 3-4-5 Triangle

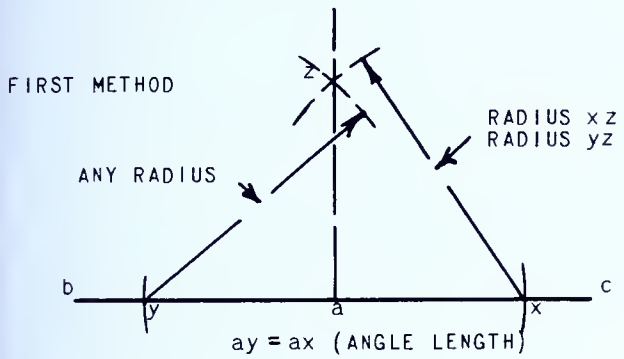
For example: At "kl" and "mn" in Fig. 133 (B), we measure out from the intersection "o", a distance as large as possible, which will still be divisible by 3. If the length "on" were 25 feet, a mark would be made at 24 feet "p". Then from "o", a length of 32 feet would be measured along "ol", making the second leg "oq".

The legs "op" and "oq" are 24 feet and 32 feet, which are in the ratio of 3 to 4 (3x8 to 4x8). The hypotenuse, or diagonal side of the triangle "pq" must then be 5x8, or 40 feet, if the angle at "o" is a right angle.

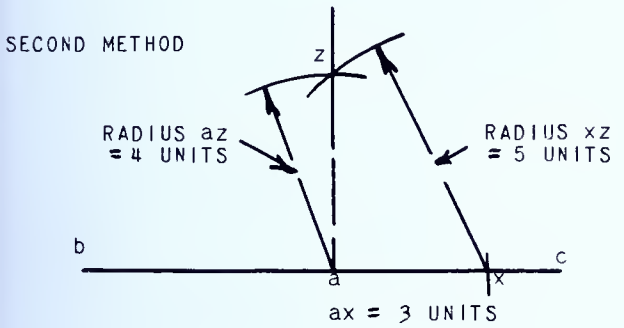
If "pq" is found to be less or greater than 40 feet, the tank top, bottom shell, or deck being checked, must be regulated again, (shifted) until the lines are square. This process of checking frame lines for squareness with the centerline is called "horning in" the deck, shell, or other portion of the ship being tested.

Note that if some obstacle, such as a foundation or other object, prevents the measuring tape from being held straight along the diagonal, the length of the three legs can be increased in the same 3-4-5 ratio to clear the obstacle. For example: in Fig. 133 (B), the legs could be 24' - 9" and 32' - 12", thus making the diagonal length 40' - 15" or 41' - 3".

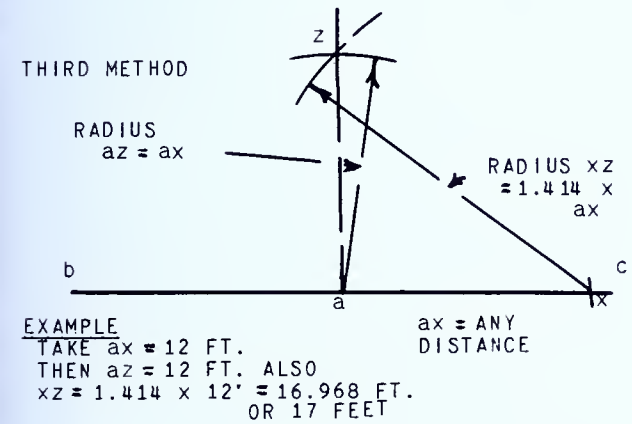
If, for any reason, the length "ol" is too short for a 32 foot leg (as in the case of a short tank section) an 18 foot leg could be used, making a 30 foot diagonal. That is, the 18, 24, and 30 are in the ratio of 3, 4 and 5, although now the longer leg is "op" and the shorter leg lies along "ol". In Fig. 134 are shown the three common methods of drawing, or erecting, a line perpendicular to another line.



1. Take "ax" equal to "ay" (any length).
2. Using "x" and "y" as centers, draw two arcs with any equal radius intersecting at "z".
3. Draw a straight line through "a" and "z". This line is perpendicular to "bc".



1. Measure "ax"=3 inches (or feet or other units) from "a".
2. Swing arc at "z" with radius 4 inches and center at "a".
3. Swing arc at "z" with radius 5 inches and center at "x".
4. Draw a straight line through "a" and "z". This line is perpendicular to "bc".



1. Measure any distance "ax".
2. Using "a" as center, swing arc at "z" with radius equal to "ax".
3. Using "x" as center, swing arc at "z" with radius equal to 1.414 times "ax".
4. Draw a straight line through "a" and "z". This is perpendicular to "bc".

Fig. 134 -- Erecting Perpendiculars

PART VI

Lifting and Installing Frames, Stiffeners, and Plates

TYPICAL FRAME AND STIFFENER CONSTRUCTION

A ship's plating holds the water out and the cargo in. The plating is stiffened by bulkheads and by a system of girders and stiffeners known as framing.

TRANSVERSE FRAMING

Most freighters have transverse framing, that is, their ribs are arranged transversely, or perpendicular to the centerline. These ribs are spaced closely (usually two to three feet apart) and braced at rather wide intervals by heavy longitudinal girders and stringers.

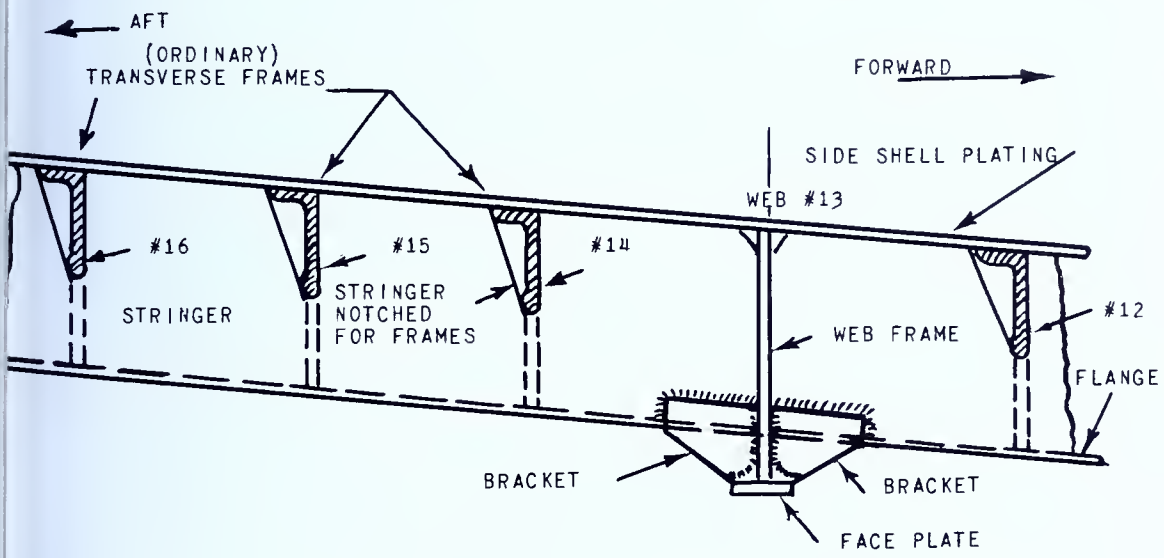


Fig. 135 -- Transverse Frames and a Longitudinal Stringer

Figure 135 shows a plan view of part of a longitudinal stringer with transverse shell frames and a heavy web frame. The heel of each bulb angle frame is on the frame line, location of which can be found in the table of offsets under the heading of "frame spacing". Also, frame spacing usually is indicated on the shell plating drawing. Frame spacing generally is smaller near the ends of a ship than at the midship section. In the case of the web frame, the drawing must be consulted to determine whether the frame line is at the forward or at the after side of the web plate. In Fig. 135, it is shown at the forward side of the plate, at web frame #13, as indicated by the light extension line.

Riveted transverse frames usually are sent to the ship with rivet holes, which permit regulating by means of the holes punched in the plates. Therefore, no frame lines need be marked, measurements being taken from the heels of the frames.

Transverse web frames which weld to the shell must be lined and tacked exactly on the frame lines. The frame lines usually are center punched at intervals on the shell plates with a marking similar to that shown in Fig. 136.

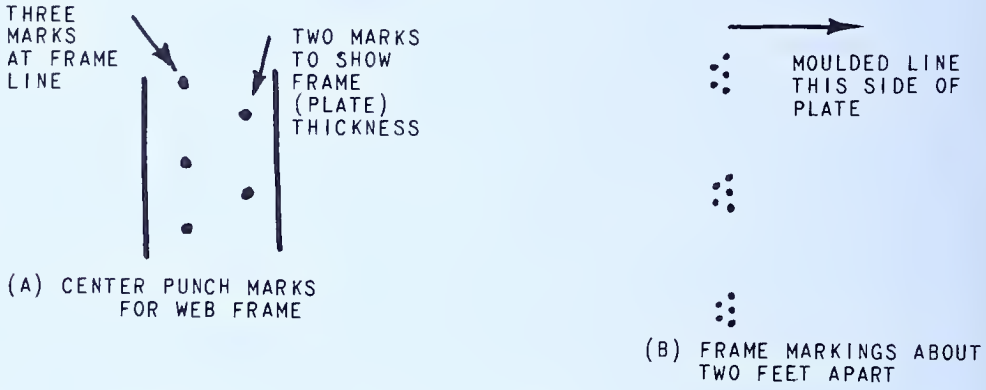

THREE MARKS AT FRAME LINE
TWO MARKS TO SHOW FRAME (PLATE) THICKNESS
(A) CENTER PUNCH MARKS FOR WEB FRAME
MOULDED LINE THIS SIDE OF PLATE
(B) FRAME MARKINGS ABOUT TWO FEET APART

Fig. 136 -- Marks for Setting Web Frames

Using this type of marking for setting frames, bulkheads, or other plates to their correct position often saves the trouble of searching the drawings to see which side of a plate is set on the moulded line. The shipfitter often uses these marks, and should be familiar with them. In taking measurements forward or aft of a frame line, extreme care must be taken to measure parallel to the centerline.

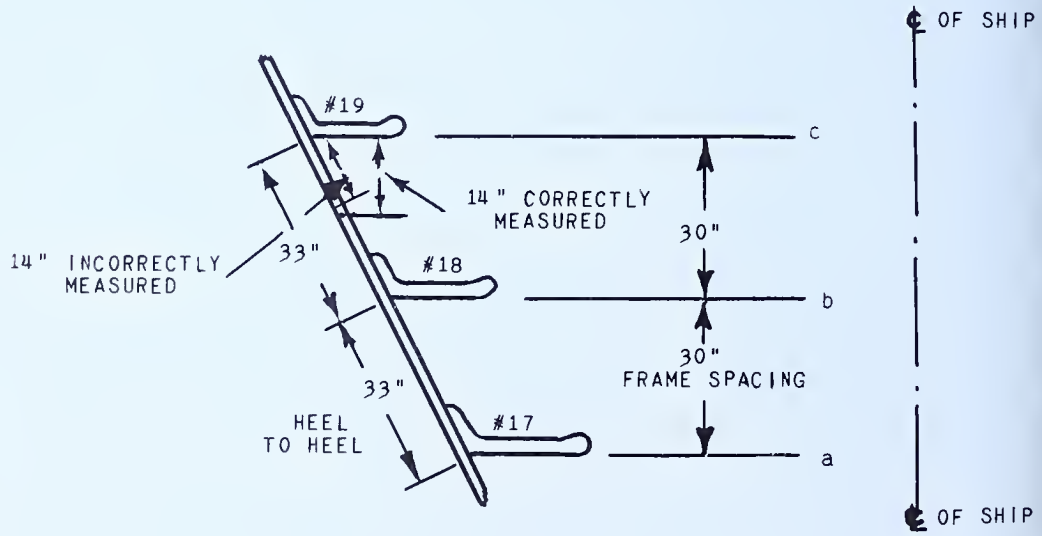


Fig. 137 -- Longitudinal Measurements from Frame Lines

Shell Frames Inside Cargo Hold

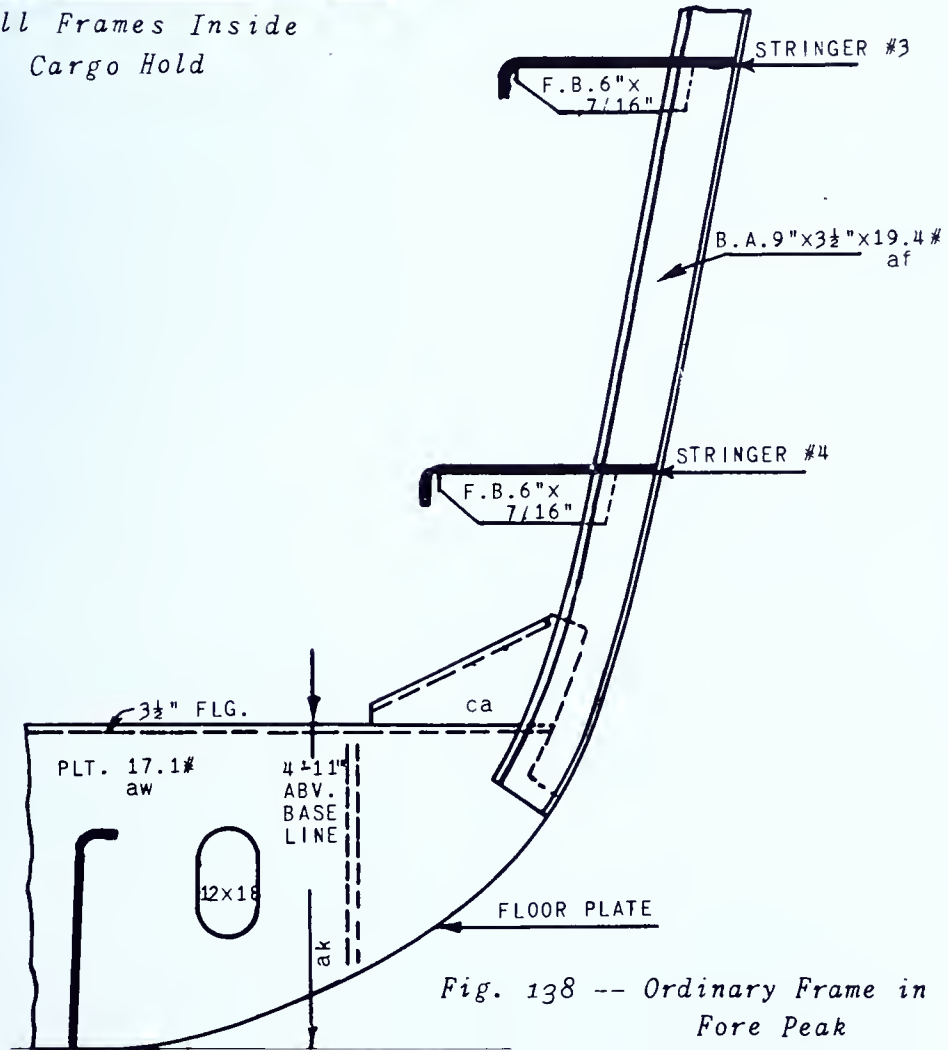


Fig. 138 -- Ordinary Frame in Fore Peak

As illustrated in Fig. 137 the frame spacing (which always is measured fore and aft) may be 30", while the distance obliquely along the shell from frame line to frame line would be 33". A hole to be cut 14" aft of frame #19 would be correct if measured parallel to the centerline, but could be over an inch out of position if measured diagonally along the shell (except where expanded measurements are specified on the plan). The frame line on a shell plate can be found by measurement from the holes punched in the plate. The gauge of the holes in the shell flange of the frame is determined from the size of the frame or preferably by measurement on the frame. To find the frame line, it is necessary only to measure this gauge distance from the center of the holes. (Of course, this must be measured in the right direction. The drawing will show whether a frame heels forward or aft. When possible, frames heel away from amidships, in order to maintain an open bevel for easier riveting.)

ORDINARY FRAMES

In Fig. 138 is illustrated an ordinary frame, as used in the forepeak of a ship. In this case it is composed of bulb angles, although channels often are used. Such shell frames are termed "ordinary frames" to distinguish them from the deep "web frames".

As shown in Fig. 138, the bottom of the shell is strengthened by a deep floor plate, "aw". Above this, is the bulb angle frame "af" which is welded to the floor plate and also connected by means of the bracket "ca". This bulb angle extends upward to the stores flat, to which it is fastened by a riveted and welded bracket "an". The bracket also is welded to the chain locker. (The chain locker is a compartment in which the anchor chain is stored.)

Beneath the stores flat, are three stringers made of flanged plates and welded to the shell. They are stiffened by means of 6" flat bars welded to the ordinary frames.

Above the stores flat, the frame is made of a lighter bulb angle, which also is bracketed to the stores flat. There is more water pressure on the outside of the hull, near the bottom, than near the surface, and therefore, the lower sections of the frames are made heavier than the higher sections. The heel of every section is on the frame line, although the gauge of the holes may change and slightly offset the line of rivet holes through the shell.

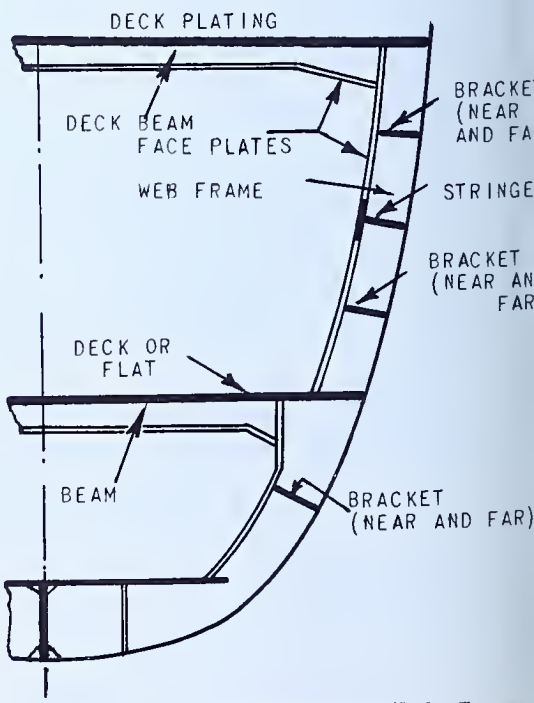


Fig. 139 -- Transverse Web Frame

In Fig. 139 is shown a web frame for a transversely framed ship. Such frames would be used at rather wide intervals along the shell, in places where extra transverse strength is required. In cargo ships, web frames and heavy beams or girders are used at the ends of cargo hatches. These extra-heavy members must carry the weight of the deck, which is supported by the longitudinal side girders of the hatches.

In Fig. 140, are illustrated three ways of fastening a web frame to the shell plating. At (A) and (B), the frame is welded.

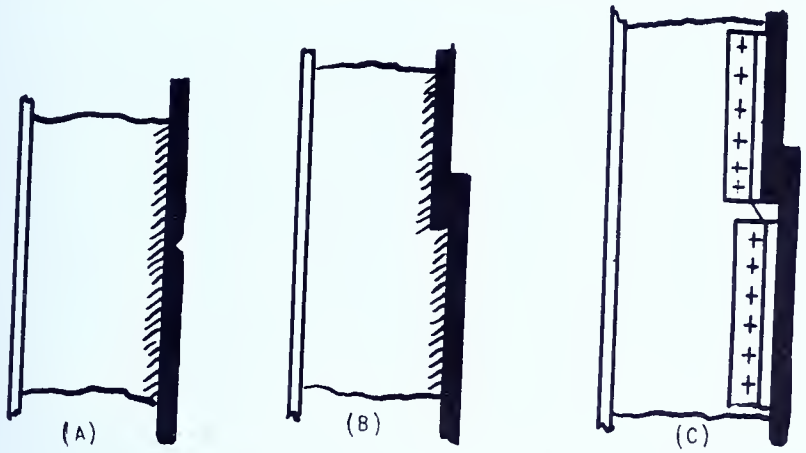


Fig. 140 -- Web Frame Fastenings to Shell

At (C), it is riveted, with shell angles cut and offset at plate laps to eliminate the need for liners.

Transverse frames are bracketed to transverse deck beams to prevent racking as explained on page 69. Ordinarily the deck beam and the shell frame heel the same way (either forward or aft), and the heel of each is on the frame line as at (A), in Fig. 141.

When marking the frame line on the deck by means of the rivet holes for the deck beam, the thickness of the bracket, "a", Fig. 141 (B), must be added to the gauge of the holes.

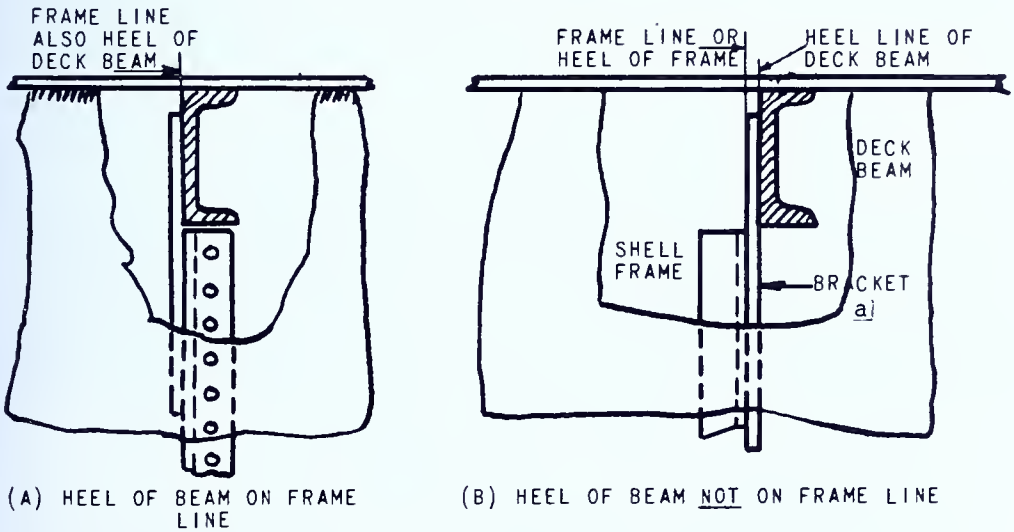


Fig. 141--Frame Lines and Deck Beam Heels

LONGITUDINAL FRAMING

In a longitudinally framed ship, the ordinary closely space stiffeners run fore and aft, and are called "longitudinals" (Shell longitudinals and deck longitudinals.) They are brace transversely at rather wide intervals by deep web frames simila to that illustrated in Fig. 139, except that these web frames mus be notched out to allow the shell longitudinals to pass through as shown in Fig. 142. Oil tankers usually are framed in thi manner (longitudinally). The longitudinals usually are welded t

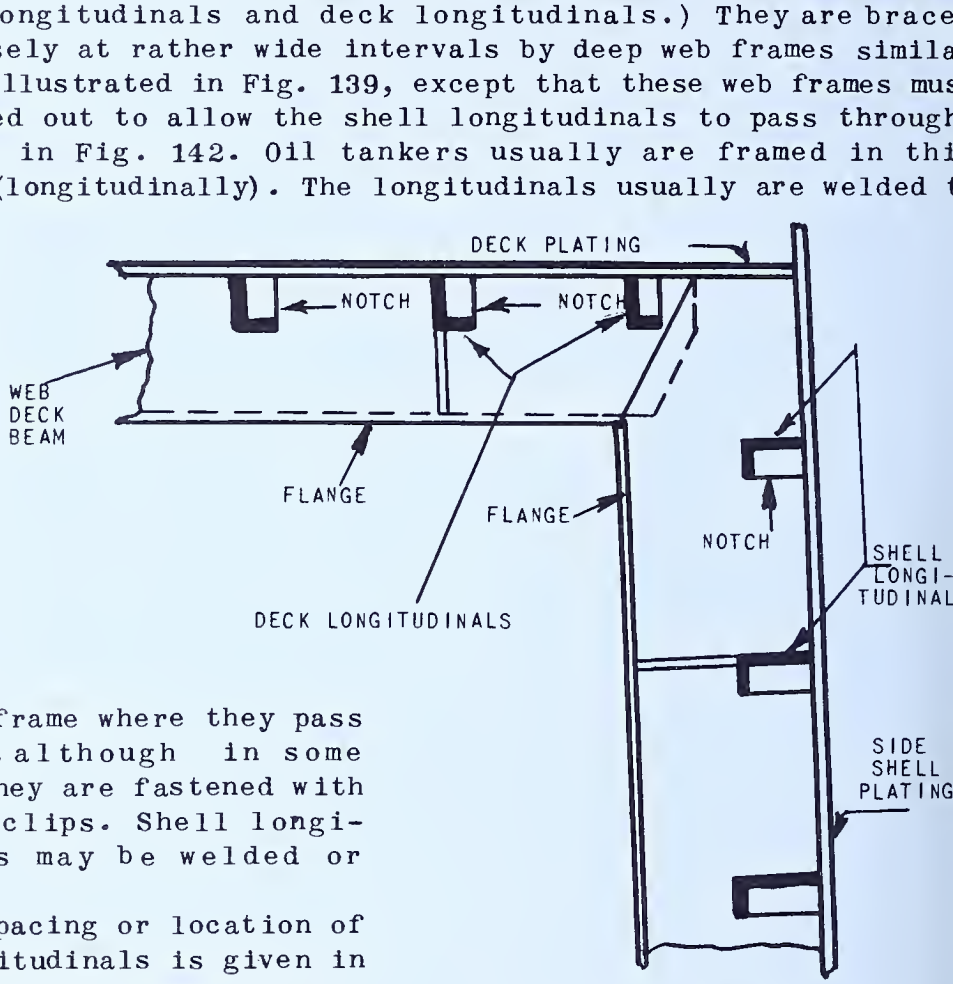


Fig. 142 -- Web Frame and Longitudinals

the web frame where they pass through, although in some cases, they are fastened with riveted clips. Shell longitudinals may be welded or riveted.

The spacing or location of the longitudinals is given in the table of offsets. This spacing changes as the longitudinals approach the ends of the ship. In laying out a web frame (in new work), the spacin of longitudinals is taken from the mold loft body plan.

Questions

1. What is the purpose of a ship's framing?
2. What is a shell longitudinal?
3. How is frame spacing determined by a shipfitter?
4. What are "web" frames?
5. How is a frame line determined on a deck supported by riveted beams?

METHODS OF LIFTING FRAMING MEMBERS

In modern shipbuilding, either for transverse-framed or longitudinally-framed ships, templates are made from mold loft lines and offsets for the ordinary frames, web frames, and longitudinals. These members are then laid out, fabricated, and assembled in the shop, and delivered to the ship, without lifting any dimensions from other parts of the hull structure. However, in repair jobs, badly damaged members must be replaced and more often than not, the mold loft work is not available. It then becomes the duty of the shipfitter to lift the shapes and dimensions required and to renew any necessary framing. Usually it is not necessary to repair both port and starboard sides of a frame at the same time.

The shape of a damaged frame, together with bevels, rivet spacings, bracket locations, etc., can be lifted from the undamaged frame at the opposite side of the ship. It must be remembered, however, that the port and starboard sides of a vessel are not alike, but are opposite; that is, one frame can be considered as being *left-handed*, while its mate is *right-handed*. This must be kept in mind and allowance made when lifting a frame from the opposite side of the ship.

TEMPLATE MARKINGS

Figure 143 shows a template for a section of an ordinary frame with the proper markings for port and starboard sides. T.S.U. Port means that in laying out the frame for the port side of the ship, the template would be applied directly as illustrated in the sketch. T. S. U. means "this side up". O. S. U. Star, means that in laying out the same frame for the starboard side of the ship, the holes must be back-marked and the template applied with the other side up, (O. S. U.), shaping the frame to the opposite hand. Other markings on the template have been previously explained.

In making a template for welded web frames, only the outline or shell shape should be picked up with a template; the plate width and other markings can be laid out on a mold loft floor, or directly on the steel.

LIFTING LONG SHAPE TEMPLATES

In making a long shape template which must be lifted in two pieces (owing to a short space for handling), set holes can be bored and tightly-fitting bolts used to fasten the pieces together as shown in Fig. 144. The template can be taken apart and reassembled in the loft or shop and properly aligned by means of tightly-fitting bolts. Fig. 145 shows a method of making a single template to clear a stringer (or other obstruction).

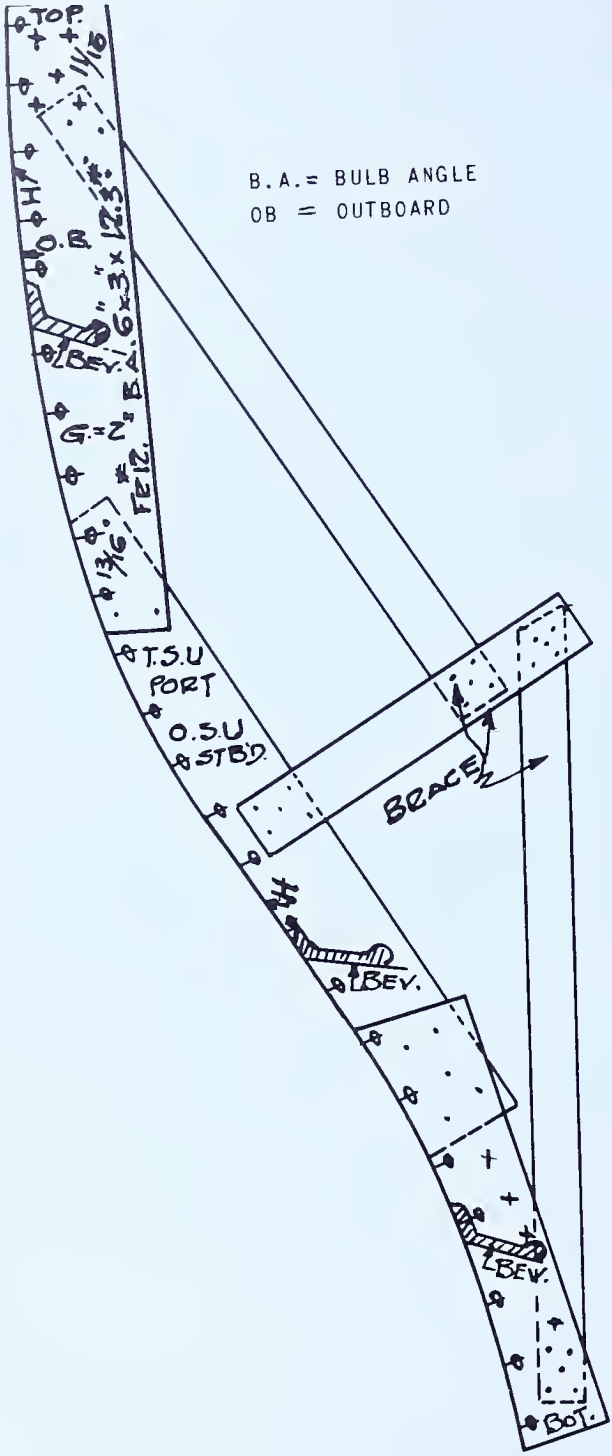


Fig. 143 -- Wood Template for Ordinary B.A. Shell Frame

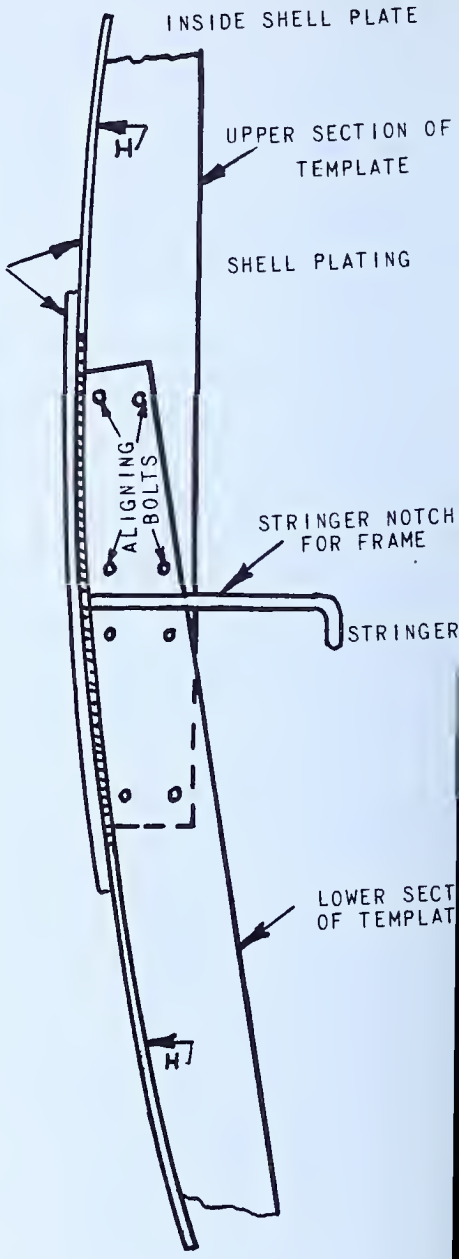


Fig. 144 -- Using Bolts to Ali
Two Sections of Frame Template

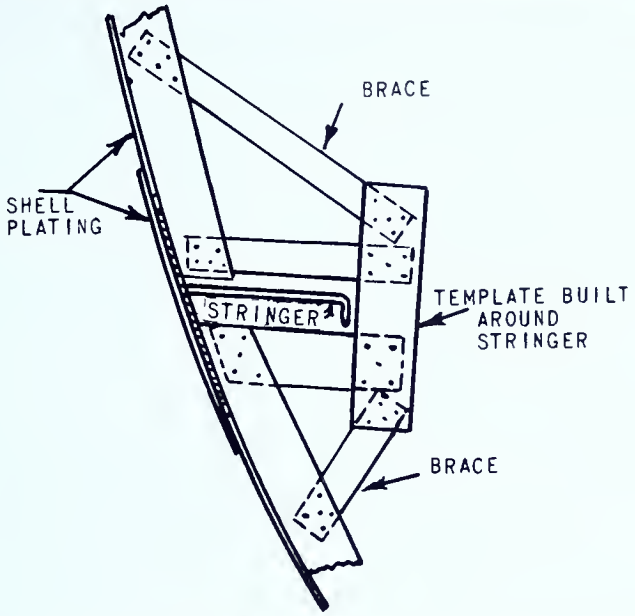


Fig. 145 -- Frame Template Made to Clear Stringer

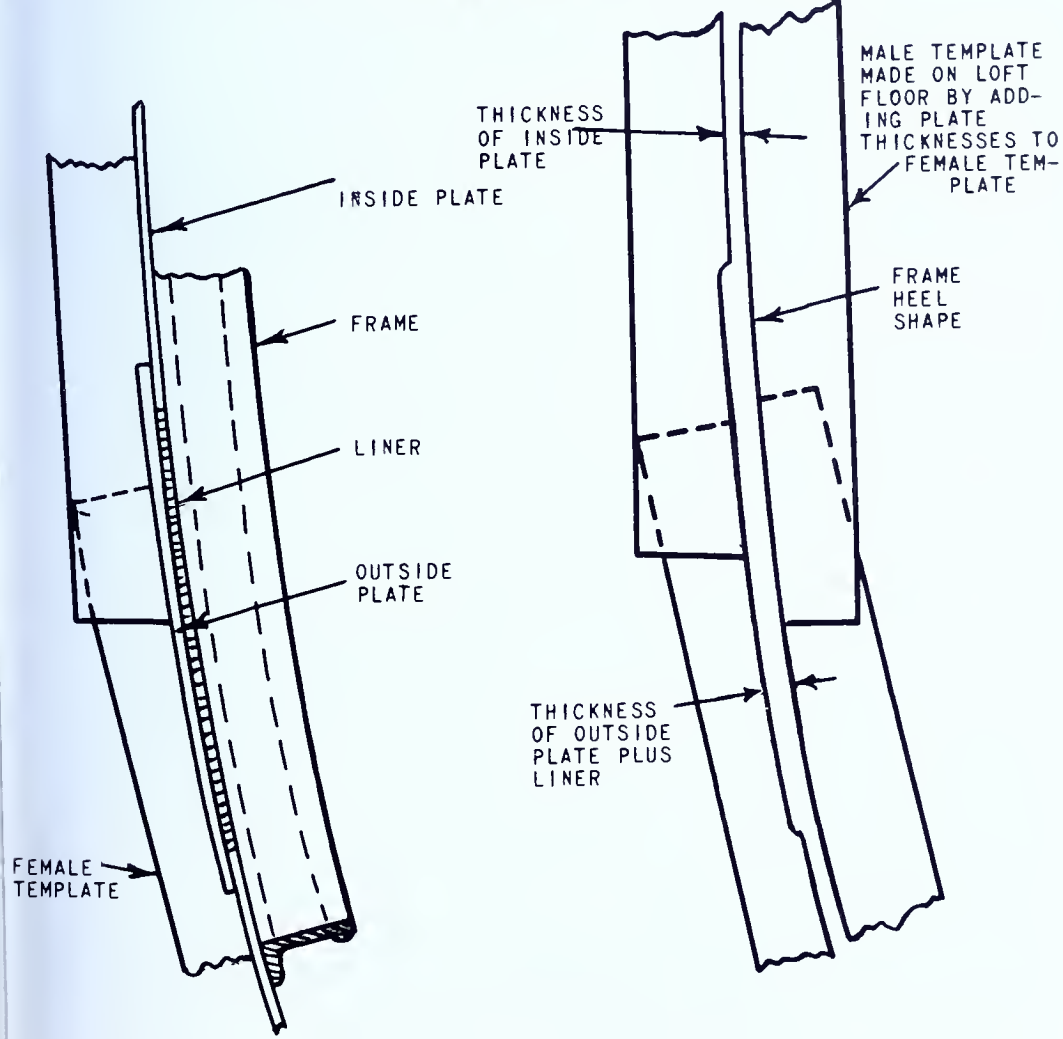


Fig. 146 -- Lifting Frame Heel Shape With Outside Template

Another way of lifting a frame shape template is to first mal a female or outside template. This is made on the outside of th shell, with plate sight edges marked. On the mold loft floor, th frame line may be laid out, adding the plate thickness where re quired to make the male template as shown in Fig. 146.

Shape templates should always be lifted at the heel line an not at the center of the rivet holes in the shell. If the ol frame has been removed, the frame line can be found by measurin over from the holes in the shell a distance equal to the require gauge of the frame holes.

REBUILDING A DAMAGED BOW

If both sides of a ship are badly damaged (as at the bow in head-on collision) and drawings are not available to give th shape of the frames, longitudinal wooden battens can be fastene to the hull sides and faired into the undamaged section. The fra outlines can then be picked up with wooden templates and a satis factory new bow built up. A more practical method, however, woul be to pick up offsets from the undamaged part of the hull and l the drawing room and mold loft draw lines for a new fair and shi shape bow. Frames, plates, stringers, etc., can then be sent o of the shop as in the building of a new ship.

LIFTING OTHER STIFFENERS

The lifting of bulkhead longitudinals, deck beams and long tudinals, and other stiffeners, involves the application of t principles previously explained with due regard for local co ditions.

Questions

1. Why are frames seldom lifted in new construction?
2. Explain the following template markings: T.S.U., BOT., BEV O.B., G = 2", H, and FR.#12.
3. Why should several set marks be used on a lifted frame te plate?
4. Seven frames on the after port side of a ship have been damage What is the best method of lifting these frames?

LIFTING SHELL PLATES

In a modern ship the majority of plates are *developed in the mold loft* by means of the body plan, offsets, and drawings. The few large plates which have to be "lifted" are not developed from the ship's lines for one of the following reasons:

(a) The moulded surface where the plate is to fit has a backset or double curvature; that is, it cannot be developed and rolled to shape from a flat plate. (A flat paper template cannot be made for a plate of this shape). Such a surface requires a "furnaced plate"; in other words, the plate must be heated and shaped or dished by a plate furnaceman.

(b) The plate is located in a position where it could easily be spoiled by the moving and regulating of other sections (such as at the turn of the bilge).

(c) The plate is to be left off to provide access to a tank or hold until the surrounding hull members are completely welded or riveted. (Sometimes the contraction caused by the welding of adjacent members changes the dimensions of the space in which the lifted plate is to fit.)

Caulking Side Shell Seam

It is very seldon that a large plate, other than a shell plate, has to be lifted in new work. Bulkhead plates usually are composed

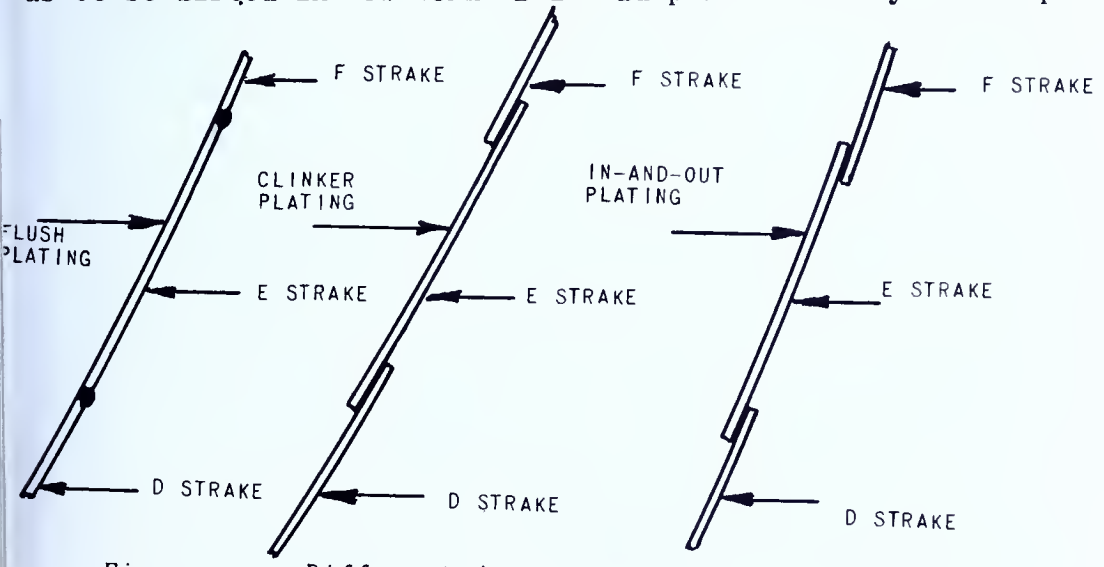


Fig. 147 -- Different Arrangements of Shell Plating

of flat, flanged, or cylindrical surfaces, which can be laid out and bent or rolled without furnacing. Bulkhead, deck, shell and other plates are often lifted in repair work.

PLATING ARRANGEMENTS

Fig. 147 shows the meaning of flush plating, "clinker" plating, and "in-and-out" plating. The ever-increasing use of welding is making the flush type more and more popular. When lifting a shell plate the important considerations are: to have the proper roll or "set" in the plate; to have the rivet holes match the corresponding holes in the frames or adjacent plates; and, to be sure that the outline of the plate is correct in order to maintain the proper landing or clearance for butt welding.

How to Lift a Template for a Shell Plate

PROCEDURE:

1. Make certain that all the members are regulated and firmly bolted or tack welded, so that there is no danger of any change in the positions of the holes.
2. Remove all the bolts which would interfere with the placing of the template.

   Any frame liners must be tightly bolted in place and tack welded before this operation.
3. Secure several strips of basswood for use in making the template.

   Basswood is the most commonly-used material for battens used in making templates. The wooden strips are about 1/4" thick and 4" to 10" in width.
4. Clamp in place the two longitudinal seam battens, "c" as illustrated in Fig. 148.

   C-clamps usually are used, as illustrated in (C), Fig. 149. Spring clips (A) and (B), Fig. 149, also are sometimes used. The rivet holes of the seams will be marked on these two strips. These two long seams have their wooden strips applied *first* because this will insure as many holes as possible in a *single piece of wood* and reduce the inaccuracies owing *to distortion of the joints* of the template. When one wooden strip is lengthened or extended by means of another strip, the length of the lap must be at least three times the width of the batten.
5. Clamp in place the longitudinal strips as illustrated at "a" in Fig. 148. These strips are used to help keep the template firm. They also keep the transverse battens "e" spaced so that their centers are very nearly at the location of the neutral surface of the plate. This effect is shown in Fig. 150. All the longitudinal strips are tight against the steel plates or liners, while the transverse strips, which are bent to a relatively sharp curvature, are close to the plate's neutral surface.
6. Tack in place the transverse frame battens "e", as illustrated in Fig. 148. Also, tack in place the battens for the end laps

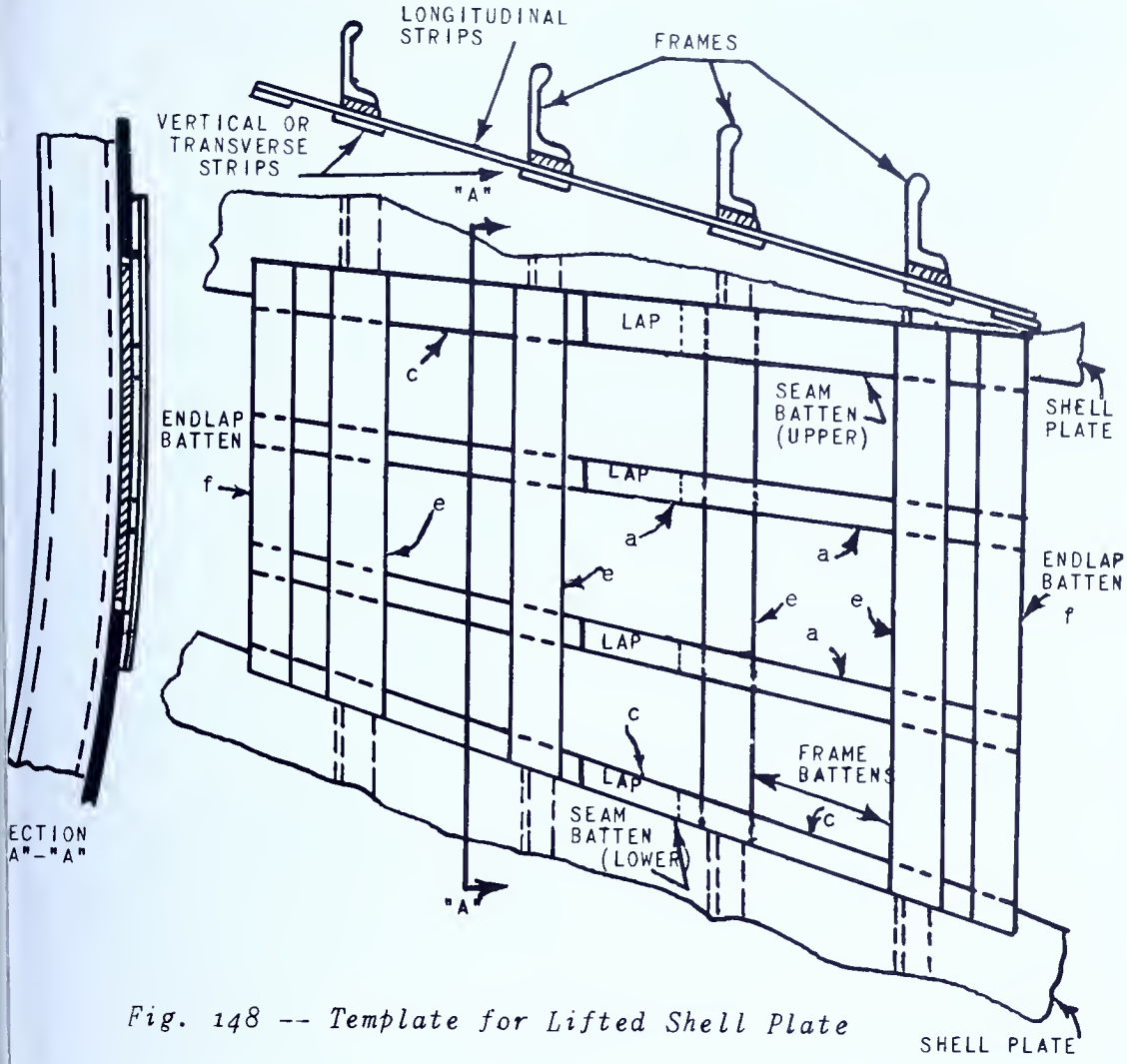


Fig. 148 -- Template for Lifted Shell Plate

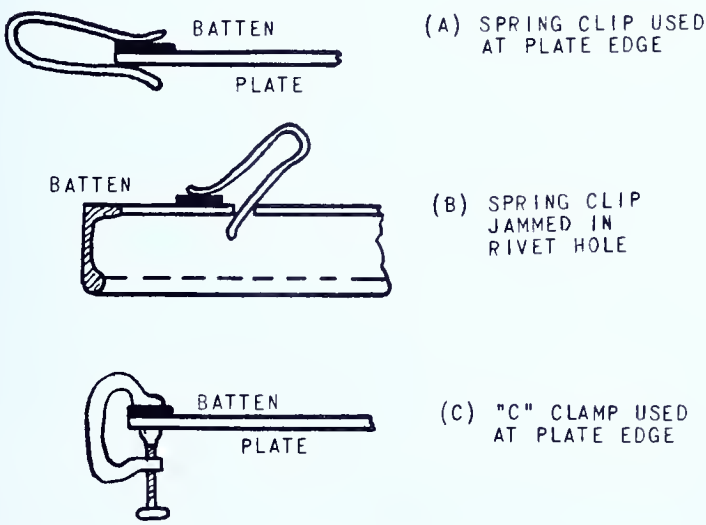


Fig. 149 -- Spring Clips and "C" Clamp

("f", Fig. 148). Every joint in the template should be fastened firmly with six to nine tacks. These tacks must have their *points clinched over,* or the joint will loosen up and become wobbly. Tacks are clinched by driving them against a steel plate or other hard surface. Templates should always be constructed so that any strip stays either on one side or the other of the strips to which it is tacked. That is, it should not go over and under like a basket weave. Correct and incorrect strip fastenings are shown in Fig. 151. Also, three-ply templates should never be used, because the neutral surface is irregular and because the tacks are not long enough to clinch over three thicknesses.

The construction at "B" would be used if the shell had more shape longitudinally than in the transverse direction. (Sometimes the condition shown at (C) cannot be avoided when a frame batten is close to a lap in the seam batten.) The thickness of the battens or strips, generally used, runs about 1/4"; therefore, the distance from the inside surface of the template to the neutral surface of these transverse battens is 3/8", which is very close to the half-thickness of most lifted shell plates. This causes the holes, as marked, to be approximately in the proper position for laying out when the template is flattened.

7. Slightly loosen the clamps and move the template about by shaking it slightly so that it will take its natural position, with none of the strips unduly restrained by the clamps.

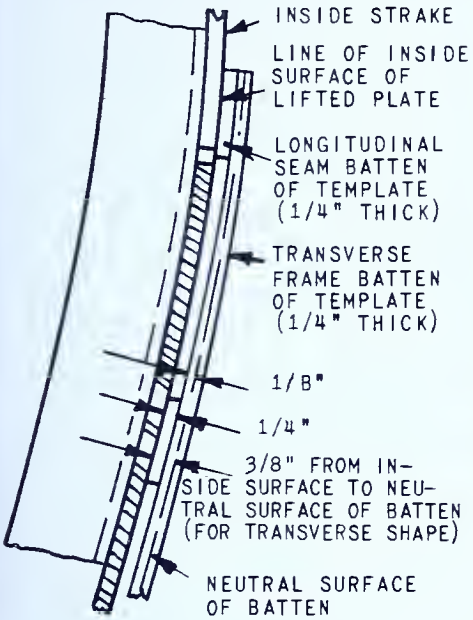
8. Re-tighten the clamps, first fastening those in the center of the plate, working from the center upward, downward, and toward both ends, so that the template will fit in place tightly and smoothly.

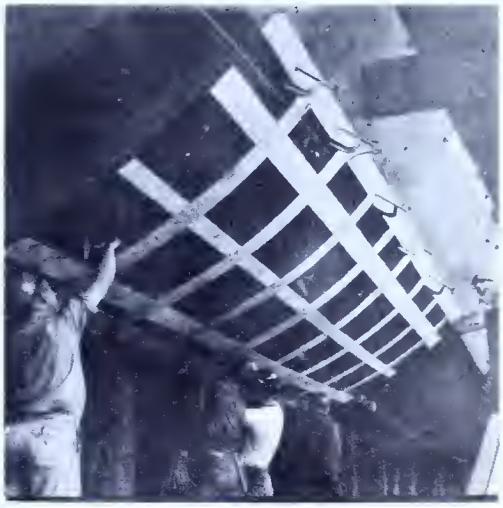
9. Mark on the template, with a pencil, all rivet holes and adjoining web frames, bulkheads, butts, etc.

In lifting two adjacent plates which butt, the blue print must be consulted to determine the location of the butt. It may be necessary to move the butt a slight distance from the specified location to clear the rivet holes in the seam above or below. This condition is illustrated in Fig. 152. When marking the butt end of one plate on the template for the adjacent plate, a wooden block is often used, as shown in Fig. 153. This block is slid along with the pencil and prevents wobbling and inaccurate marking of the beveled butt of the plate. If the template is very long, a straight line should be marked on it, so it can subsequently be properly aligned without any sagging.

If the plate cannot be laid out immediately, check marks and dimensions should be clearly marked on the template before it is stored. Lengths of the four sides are usually marked, and sometimes, also, the width at the center of the plate.

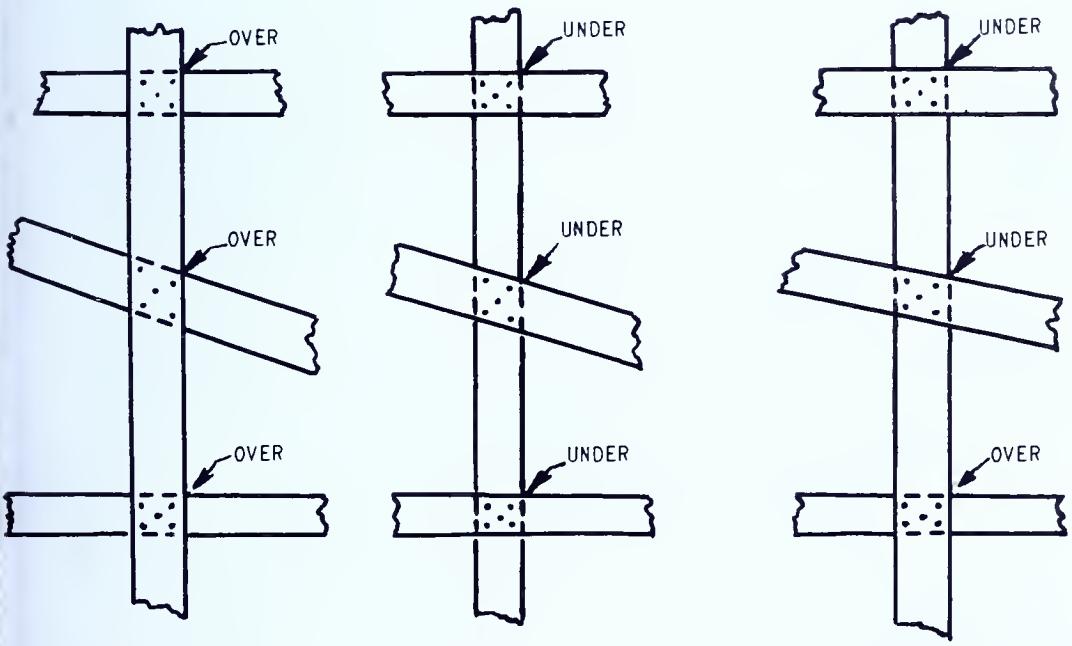
10. Remove clamps and take template to shop for laying out plate.


INSIDE STRAKE
LINE OF INSIDE SURFACE OF LIFTED PLATE
LONGITUDINAL SEAM BATTEN OF TEMPLATE (1/4" THICK)
TRANSVERSE FRAME BATTEN OF TEMPLATE (1/4" THICK)
1/8"
1/4"
3/8" FROM INSIDE SURFACE TO NEUTRAL SURFACE OF BATTEN (FOR TRANSVERSE SHAPE)
NEUTRAL SURFACE OF BATTEN



Lifting a Bilge Plate

Fig. 150 — Placing of Strips for Shell Plate Template



(A) CORRECT VERTICAL STRIP GOES OVER OTHER STRIPS

(B) CORRECT VERTICAL STRIP GOES UNDER OTHER STRIPS

(C) POOR PRACTICE VERTICAL STRIP GOES UNDER TWO AND OVER THE THIRD

Fig. 151 — Placing Wooden Strips for Shell Plate Templates

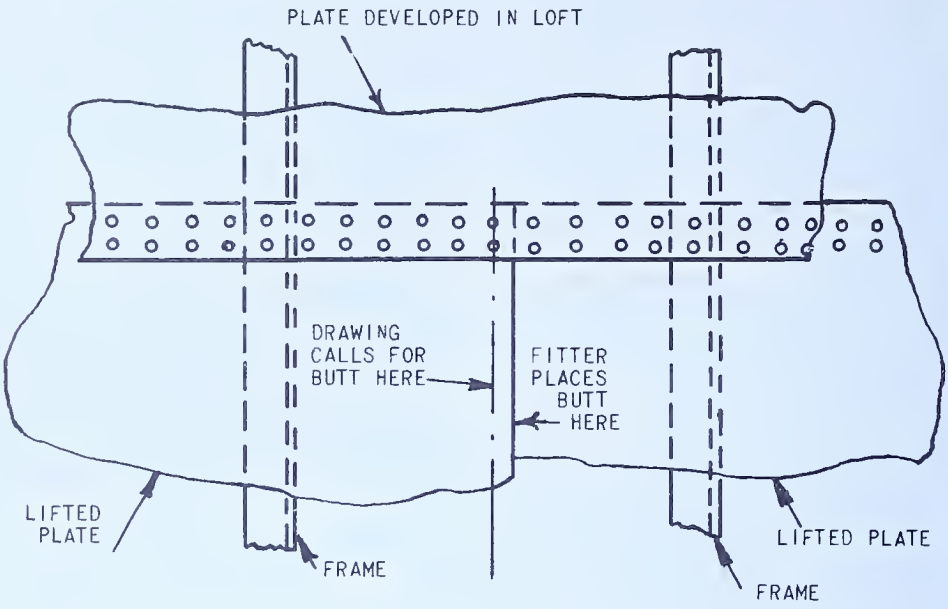


Fig. 152 — Moving Butt to Clear Rivet Holes

Questions

1. Why is it sometimes necessary to lift shell plates?
2. What is "clinker" plating?
3. Why are long battens applied first when building a template?
4. What would be the disadvantage of having three thicknesses of batten?
5. Why should the template be loosened and shaken before markings are applied?
6. When possible, why should a plate be laid out on the same day thatthe template is lifted?

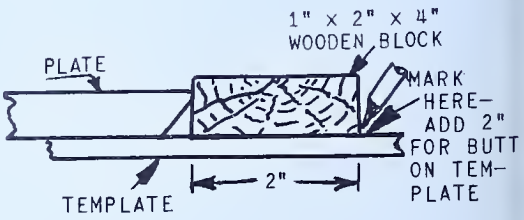


Fig. 153 — Marking Welded Butt on Template

USE OF ROLL SETS

Roll sets or roll templates are made to the shape of the inside of the plate at the frame lines. If the roll is not the same throughout the plate, a roll set is made for the last frame at each end of the plate and also one or more intermediate frames. These, if necessary, can be made from the outside of the hull (female templates) as previously explained, but the male templates must be made for the man at the rolls. In new work, these roll sets are made from the body plan in the mold loft.

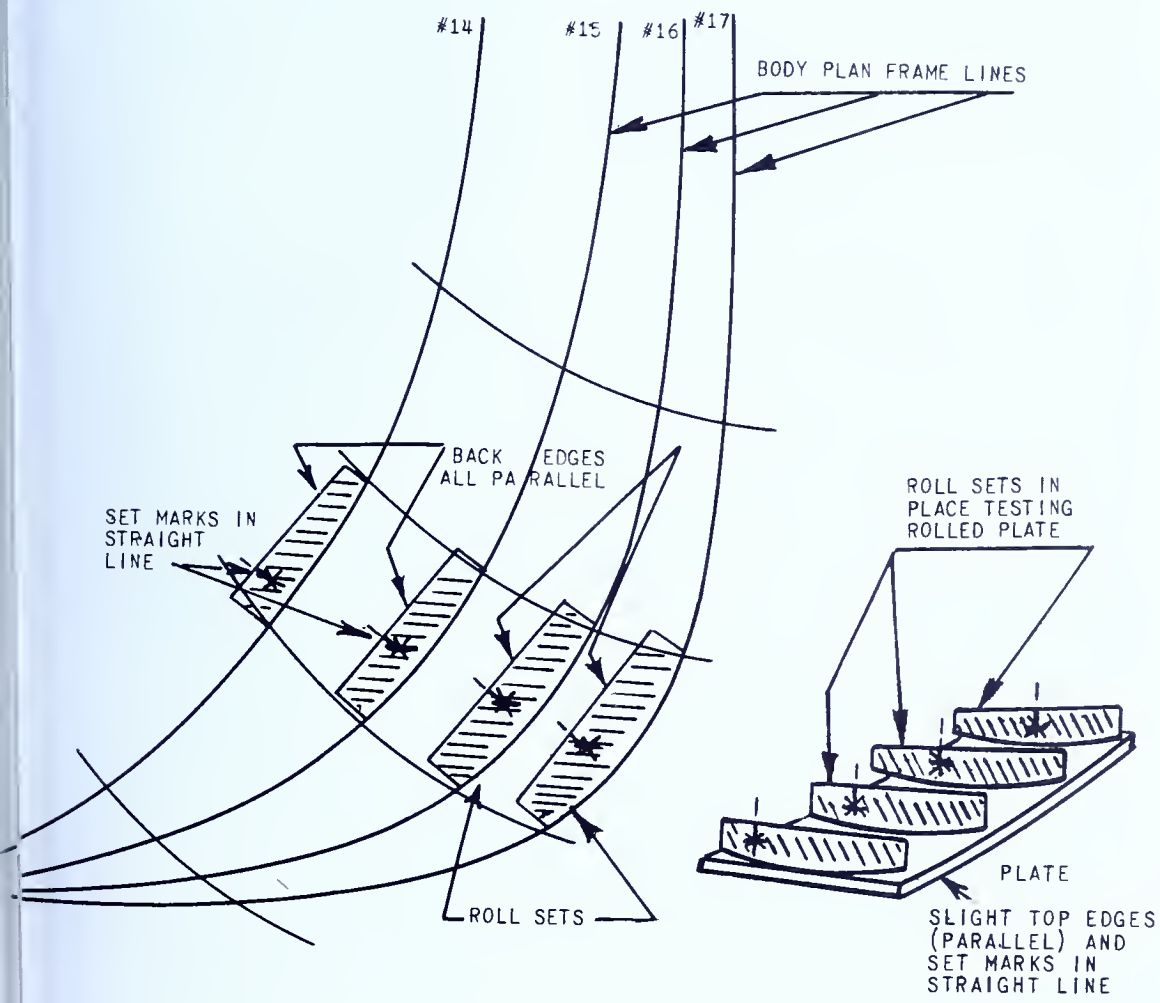


Fig. 154 — Roll Sets for Lifted Plate

In order to get the proper twist in the plate, the roll sets for any plate are constructed so that each has one edge parallel to the corresponding edges of the other roll sets, as illustrated in Fig. 154. In other words, these flat edges all are in one plane

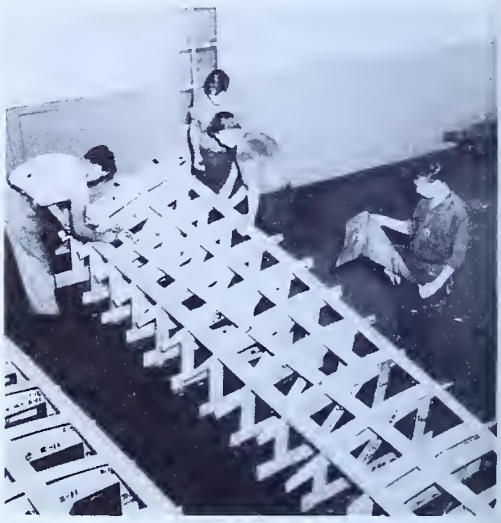
when set on the rolled plate, and can easily be aligned by sighting across their tops. The set marks also can be aligned very accurately by eye.

FURNACED SHELL PLATES

The template for a furnaced shell plate can be made from mold-loft lines by constructing a "mock-up mold", or built up framework of wood which accurately reproduces the shape of the framing or moulded surface. This is not often done since it usually is easier to lift the plate by means of a template lifted from the ship. The latter method also reduces or eliminates possible unfair holes caused by regulation or distortion.

Questions

1. When possible, why are roll sets made in the mold loft?
2. What is a "mock-up?



Apprentice Boys Making a Mock-Up Mold in Shipfitting School

HOW TO LAY OUT A LIFTED SHELL PLATE

PROCEDURE:

1. Secure a plate of proper thickness which is sufficiently large for the needed plate.
2. Apply the template to the plate, and fasten with "C" clamps.
   If the template is very long, the straight line placed on the template at the time the template was lifted, should be checked for straightness. If it has been slightly racked or misaligned, the template must be readjusted to straighten the line. Check marks for length and width should also be verified at this time. A shell plate should, whenever possible, be *laid out the same day that the template is lifted*; otherwise, there may be inaccuracy caused by shrinkage of the template.
3. Mark on the steel the outline of the plate, frame lines, butts, etc.
   If a block is used for marking the template, (as previously explained for welded plate), the width of the block must be added outside the line on the template. This new line is then punched through the wood so as to mark directly on the steel plate.

4. Lay out the location of rivet holes on the steel by punching through template onto steel plate with a wood punch.

When the plate is laid out, the holes should be punched the same size as the holes in the frames and adjacent plates, except in repair work, where the old holes have already been reamed full size. In this case, the holes are punched smaller in the lifted plate, with a few holes punched to full size for regulating. It was previously explained that, owing to the location of the neutral surface of the template, plates lifted as above might have very little "draw" or moving of the holes when the template is flattened. However, when this template is transferred to the opposite side of the ship to pick up the holes for the other shell plate, this effect is entirely changed. Also, in the parallel middle body of a vessel, it is usual to use the same template for lifting the holes on three or four different plates (marking with different colored pencils). For these reasons, the spacing of the holes in each frame is always picked up on a "girth stick", which is merely a strip of wood of the same thickness as the required plate. This girth stick is applied as shown in Fig. 155, and the holes are marked on it. It is then used to check the spacing of the frame holes as laid out from the template. By using pencils of different colors, the same girth stick can be used for all the frames on one plate. Also, the cross section of the girth stick generally is made square, so all four sides can be used. The holes, as laid out from the template, are held the same at the center of the girth of each frame, and those near the end of the girth (that is, toward the top and bottom edges of the plate) are pulled in to match the girth stick. The template marks are always moved on the steel to agree with the girth stick marks.

5. Transfer to the steel all location, identification, and other markings, as illustrated in Fig. 156.

6. Have plate sheared and punched, and countersunk, if required. Have plate rolled if necessary.

Questions

1. How is a girth stick used?

2. What do the following marks indicate:

AE, CKOS, Roll up, and E6?

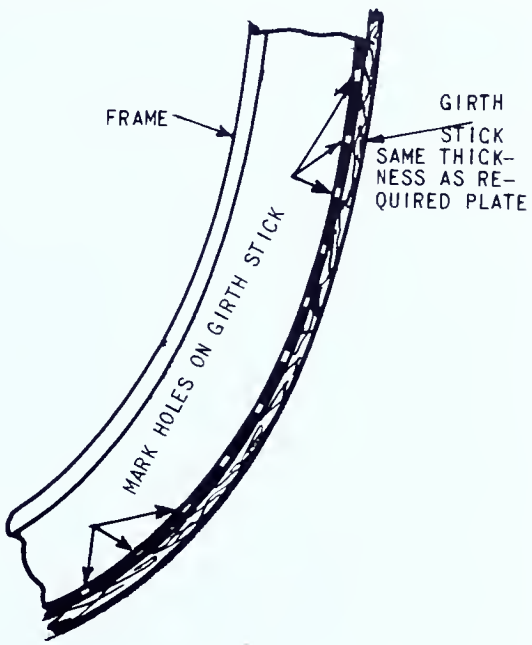


Fig. 155 -- Use of Girth Stick

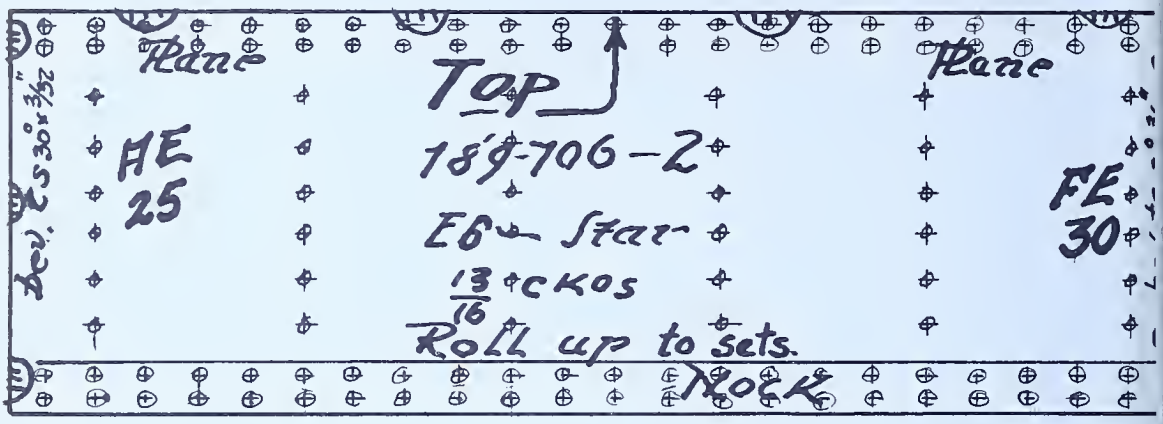
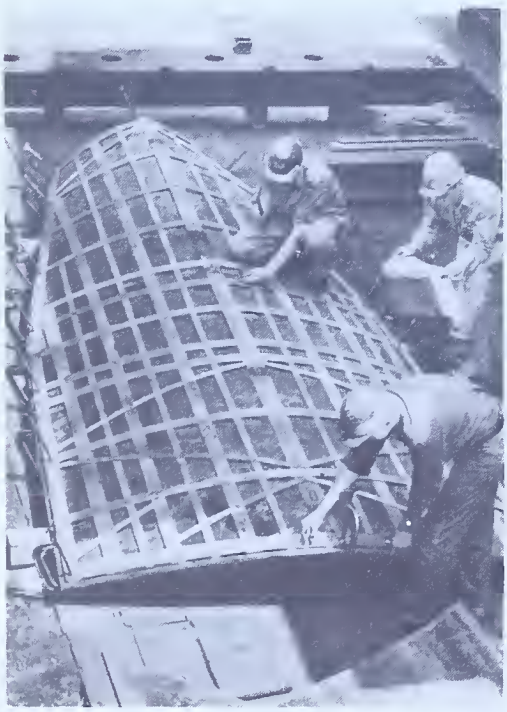
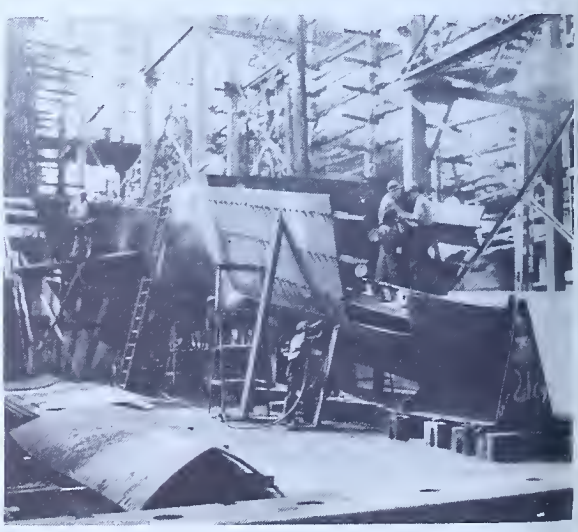


Fig. 156 -- Typical Plate Layout

FURNACED PLATES

A furnaced plate is one which cannot be developed and rolled to shape from a flat plate. This occurs when a plate must have a back-set or double curvature. Such a plate usually must be heated and shaped or dished by a plate furnaceman. Bulbous bow plating usually requires furnacing.





(Above) Bow Assembly
(Left) Laying Out a Furnaced Shell Plate

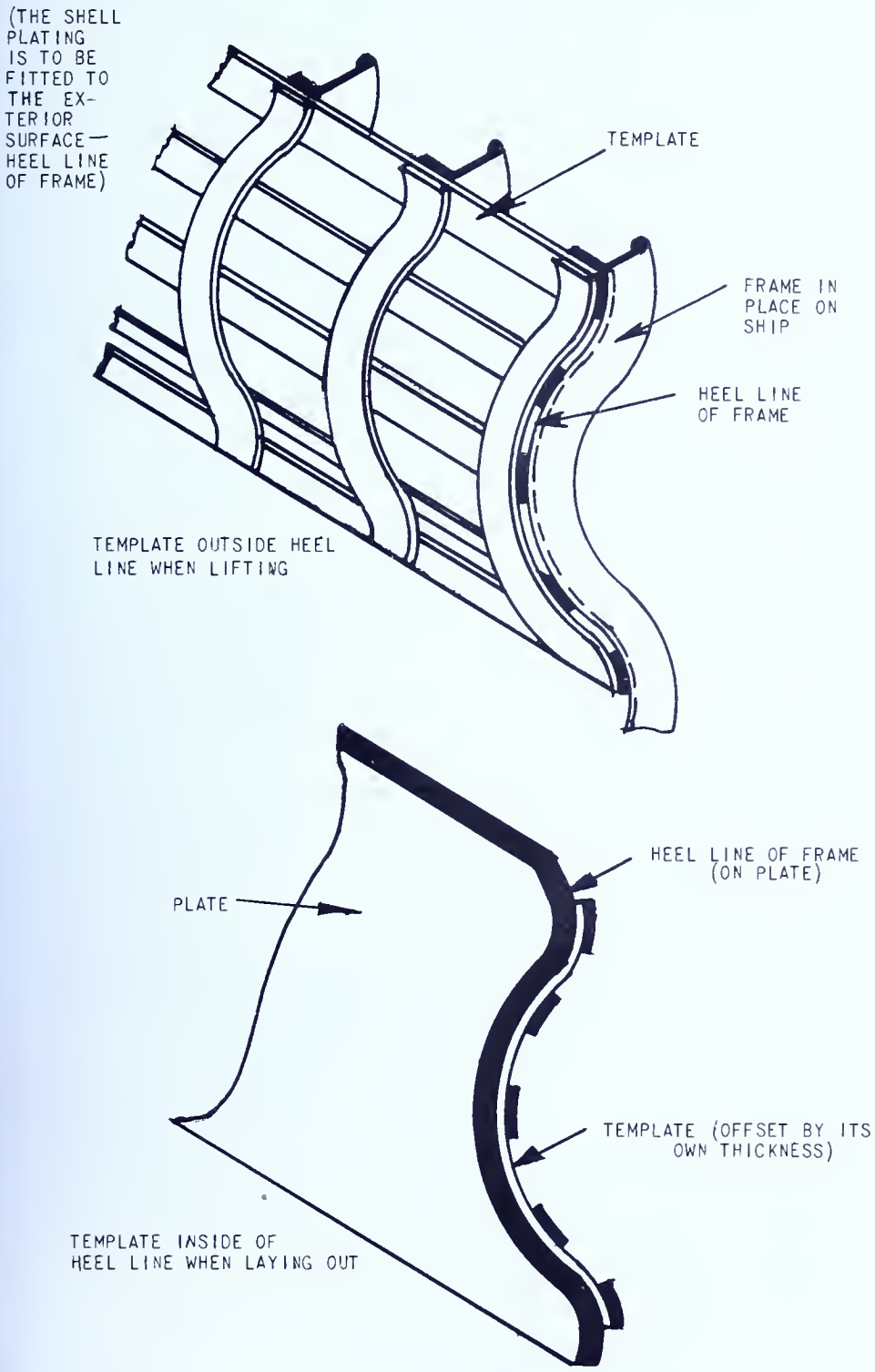

(THE SHELL PLATING IS TO BE FITTED TO THE EXTERIOR SURFACE — HEEL LINE OF FRAME)
TEMPLATE
FRAME IN PLACE ON SHIP
HEEL LINE OF FRAME
TEMPLATE OUTSIDE HEEL LINE WHEN LIFTING
HEEL LINE OF FRAME (ON PLATE)
PLATE
TEMPLATE (OFFSET BY ITS OWN THICKNESS)
TEMPLATE INSIDE OF HEEL LINE WHEN LAYING OUT

Fig. 157 -- Laying Out a Furnaced Shell Plate

LAYING OUT A FURNACED PLATE

Holes, butts, etc., on a furnaced plate never should be laid out for drilling or shearing until the rolling and furnacing is done. This is necessary because the neutral surface of the plate actually *changes in length* during the heating and shaping process.

The procedure, when girthing such a plate, is entirely different from the ordinary use of a girth stick. In laying out holes in a plate already shaped, the neutral surface has no effect, since the template is bent to the *same shape* both in lifting the holes and in laying them out. (See Fig. 157). The thickness of the template draws the holes a large amount *owing to the total thickness of the template.* A thick girth stick would give a similar but more pronounced error. Therefore, the girthing template used must be *as thin as possible*, and for this purpose red template paper is commonly used. This thin girth template is applied to the plate after the furnacing is completed. It must be laid flat against the inside surface of the furnaced plate where it is to contact the frame.

How to Lay Out a Furnaced Plate

PROCEDURE:

1. Secure the furnaced plate which is to be laid out, together with corresponding template and girthing templates. These girthing templates are made on red template paper.
2. Apply template to the furnaced plate and fasten with "C" clamps.
3. Mark on the steel the outline of the plate, frame lines, butts, set marks, rivet holes, etc.
4. Remove template.
5. Apply girthing template, matching set marks on girthing template and on steel.
6. Correct the location of rivet holes by moving rivet marks taken from the first template to coincide with the location of holes as marked on girthing template.

   Final location of rivet holes should be center punched and made easy to find by placing a ring around each punch mark. Note: Welded construction eliminates the use of rivets and the necessity of locating rivet holes.

Questions

1. What is a "furnaced" plate?
2. Why are holes and butts not laid out before furnacing a plate?
3. Why should a furnaced plate be girthed with a thin template?

BACKSETTING PLATES

Rolling, backsetting, and furnacing of plates are operation which are not performed by the shipfitter. However, an under

BACKSETTING BY PACKING ROLLS

Shell plates which have a backset, or double curvature, are ordinarily furnaced plates. However, by "packing" the rolls, it is possible to put some backset in a plate without heating.

The plate is first rolled to a shape as nearly correct as possible without any backset. It is then removed from the rolls and steel packing applied as shown in Fig. 158. The packing is so con-

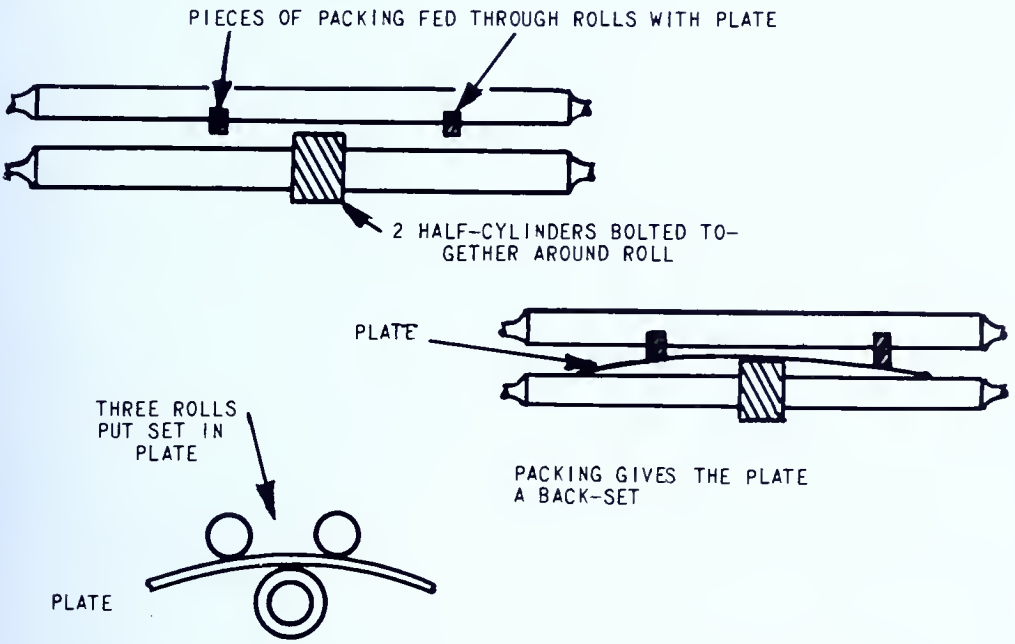

PIECES OF PACKING FED THROUGH ROLLS WITH PLATE
2 HALF-CYLINDERS BOLTED TOGETHER AROUND ROLL
PLATE
THREE ROLLS PUT SET IN PLATE
PACKING GIVES THE PLATE A BACK-SET
PLATE

Fig. 158 — Packing Rolls to Put Backset in a Plate

structed that two half-cylinders bolt together, fitting loosely around the roll. The packing on each roll can be moved or adjusted lengthwise, permitting the plate to be gradually worked into shape. The plate is put into the packed rolls and fed back and forth, the rolls being tightened a little each time, until the plate has the correct set, backset and twist.

FURNACING PLATES

For deeply dished plates, bulbous bow plates, etc., it usually is necessary for a plate furnaceman to heat and shape the steel. He is furnished with "sets" and template by the shipfitter, or mold loft, and builds a steel form on which the plate can be fastened and shaped. (See Fig. 159.) The backset can sometimes be forced into the plate by means of one of the methods illustrated in Fig. 160 (A) and (B).

Questions

1. How are rolls packed for backsetting a plate?
2. What is the purpose of a plate furnaceman's form?

THE HOT PLATE IS LAID OVER THIS FORM AND HAMMERED OR PRESSED DOWN TO SHAPE
STEEL FORM BUILT UP OF SCRAP PLATES AND FLAT BARS

Fig. 159 -- Plate Furnaceman's Form

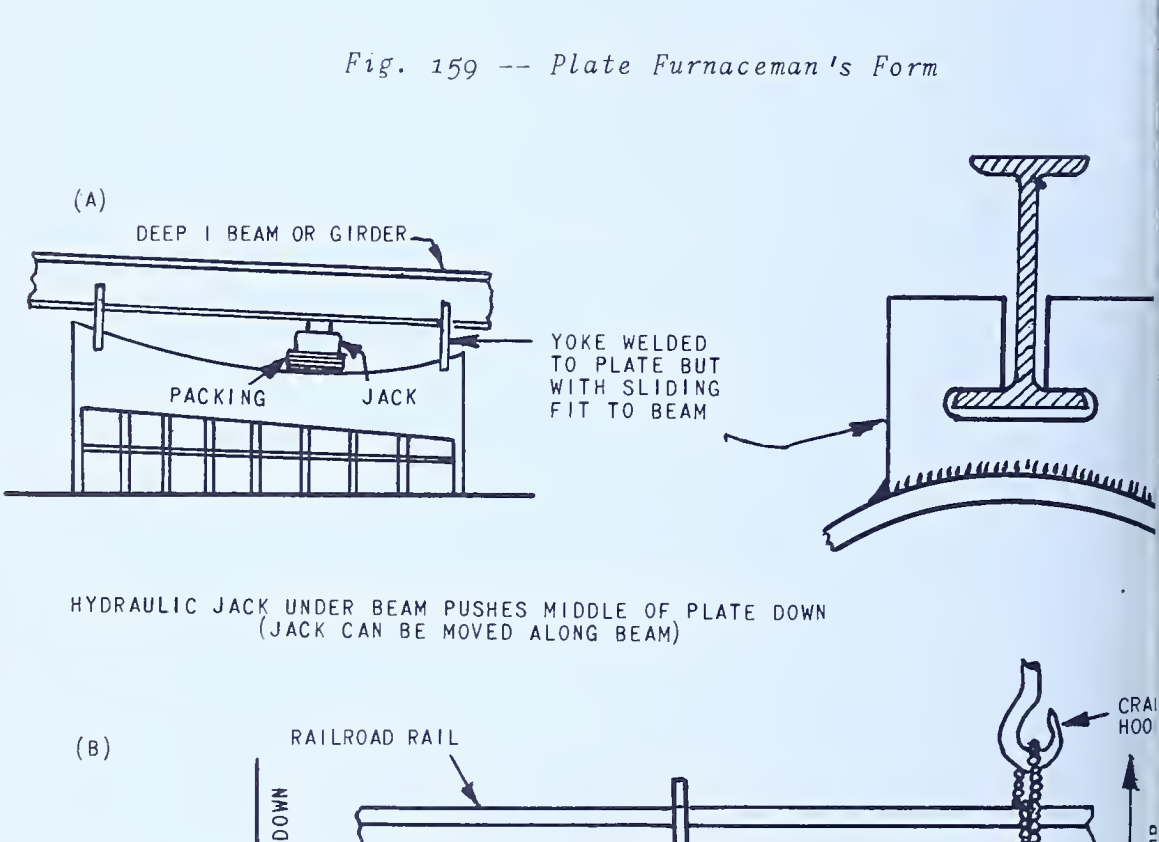


Fig. 160 -- Methods of Putting Backset in a Plate

PLATE THICKNESSES AND WEIGHTS

The thickness of shell or other plates usually is designated in pounds per square foot. A steel plate 1" .thick weighs 40.8# (pounds) per square foot. For every 1/8" in thickness, the weight per square foot is 5.1#. Table XII gives these weights for every 1/64" in thickness.

Table XII -- Thicknesses and Weights of Steel Plate

THICKNESS IN INCHES	WEIGHT IN LBS. PER SQUARE FT.	THICKNESS IN INCHES	WEIGHT IN LBS. PER SQUARE FT.
1/64	.638	53/64	21.05
1/32	1.28	17/32	21.7
3/64	1.91	35/64	22.3
1/16	2.55	9/16	22.95
5/64	3.19	37/64	23.6
3/32	3.83	19/32	24.25
7/64	4.46	39/64	24.87
1/8	5.10	5/8	25.5
9/64	5.74	41/64	26.18
5/32	6.38	21/32	26.8
11/64	7.02	43/64	27.4
3/16	7.65	11/16	28.05
13/64	8.30	45/64	28.7
7/32	8.93	23/32	29.35
15/64	9.58	47/64	30.0
1/4	10.20	3/4	30.6
17/64	10.85	49/64	31.26
9/32	11.50	25/32	31.9
19/64	12.12	51/64	32.5
5/16	12.75	13/16	33.2
21/64	13.40	53/64	33.8
11/32	14.03	27/32	34.4
23/64	14.68	55/64	35.1
3/8	15.30	7/8	35.7
25/64	15.95	57/64	36.4
13/32	16.60	29/32	37.0
27/64	17.22	59/64	37.6
7/16	17.85	15/16	38.25
29/64	18.5	61/64	38.9
15/32	19.14	31/32	39.6
31/64	19.79	63/64	40.2
1/2	20.4	1	40.8

Table XIII -- Breadths of Seams, End Laps, and Butt Straps
(Courtesy "Lloyd's Register of Shipping, Rules And Regulations, 1939-40".)

THICKNESS OF PLATES	.36 & under	Above .36 & not over .50	Above .50 & not over .72	Above .72 & not over .94	Above .94 & not over 1.14	Abo 1.1 not 1.2
Diameter of rivets	5/8"	3/4"	7/8"	1"	1-1/8"	1-1
Quad. Riv. Butt Straps	-	-	22	25	28¼	31
Treb. Riv. " "	-	14¼	16⅜	19	21½	24
Doub. Riv. " "	8	9⅜	11¼	-	-	-
Single Riv. " "	4½	5¼	-	-	-	-
Quint. Riv. End Laps	-	-	15	17½	20	22
Quad. Riv. " "	-	-	12	14	16	18
Treb. Riv. " "	6	7½	9	10½	12	13
Doub. Riv. " "	4½	5	6	-	-	-
Single Riv. " "	2½	3	-	-	-	-
Treb. Riv. Seams	-	-	-	8½	9½	10½
Doub. Riv. "	3⅜	4½	5¼	6	6⅜	7½
Single Riv. "	2¼	2½	3	-	-	-

Table XIV -- Breadths of Seams, End Laps, and Butt Straps.
(Courtesy American Bureau of Shipping, "Rules For Building and Classing Steel Vessels".)

	.18 & under .24	.24 & under .36	.36 & under .52	.52 & under .72	.72 & under .94	.94 & under 1.14	1.14 unde 1.20
Size of rivets	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/
Single Riv. Seams	2	2¼	2½	3	3½	4	-
" Riv. End Laps	2¼	2½	3	3½	-	-	-
Zig Zag Riv. Seams	3	3¼	3⅜	4-3/8	5	5-5/8	6¼
Double Riv. "	3½	3⅜	4½	5¼	6	6⅜	7½
" Riv. End Laps	3⅜	4-3/8	5¼	6-1/8	7	-	-
Treb. Riv. " "	-	6-1/4	7½	8⅜	10	11¼	12½
Quad. Riv. " "	-	-	10¼	11⅜	13½	15¼	17
Quint. Riv. " "	-	-	-	-	17	19½	22
Doub. Riv. Butt Straps	-	8	9⅜	11-3/8	13	-	-
Treb. Riv. " "	-	-	14¼	16-1/2	19	21½	-
Quad. Riv. " "	-	-	18⅜	22	25	28	31½
Quint. " " "	-	-	-	-	31	35	39
Min. Landing 1-1/2 x dia. of rivet (Center of riv. to edge of plate)							
Min. Distance between adjacent rivs. in seams 2-1/2 x riv. dia.) straps 3 x riv. dia.)A.B.S end laps 3½ x dia. riv.)							

PART VII

Castings, Foundations, Gratings, and Floor Plates

CASTINGS USED IN SHIP CONSTRUCTION

A casting is a metal article which has been formed by pouring olten metal into a mold or form and allowing it to cool and arden (allowing for shrinkage when making pattern).

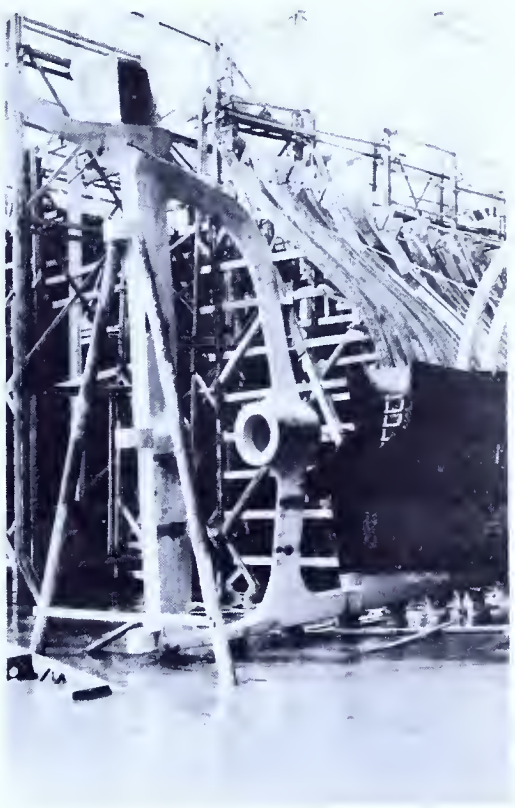
Usually the mold is made of sand, either damp (green) or baked nd dried. "Loam molds" are built of bricks and faced with loam. he latter are used for large complicated and important castings uch as steam cylinders and propeller blades. Dry sand moulds make astings similar in quality to loam moulds, and are generally used or stern frames and hawse pipes.

Cast steel and forged steel ay readily be welded by the ame methods used for ordinary tructural steel. Cast iron and alleable iron cannot be welded n the usual way, although they re sometimes welded by taking pecial precautions.

Aluminum, brass, bronze, and opper can be welded by using he proper electrodes and cur- ents.

The use of electric welding n the shipyard has greatly re- uced the number of castings hich are built into the hull of ship. At the present time, the argest and most important hull tructural member to be cast is he stern frame. Next largest re the stem, hawse pipes and ea chests.

Other smaller members which re still usually cast are tores and other davits and heir pedestals, rudder carrier, hocks, mooring pipes, fair- eads, some hatch covers, manhole covers, portlights, and various mall fittings for railings, awnings, rigging, etc. The stern rame of a modern large ship is generally composed of several astings welded together. The necessary templates are made in the



View of Stern Frame

mold loft, where dimensions are taken from the drawings and fro the lines on the mold loft floor. The castings are made at th foundry and sent to the shipyard, where it becomes the duty of th shipfitter to assemble and fit the pieces. When the stern frame i assembled and welded together, it must be erected and fastene rigidly in place with shores and guy wires. Owing to the fact tha castings shrink when cooling and often contract unevenly, it usual ly is found that two large similar castings, even when made fro the same pattern, will vary in dimensions. Steel castings shrin about 3/16" per foot of length, and allowance is made for thi when making the patterns, although very large castings, such a stern frames and hawse pipes, cannot be depended upon for exact measurements unless stock is left on for machining after in- stallation. This is done at the propeller shaft eye and at the rudder carrier and rudder gudgeons.

This machining would be too expensive a process to be carried out where all the hull members, such as frames, bulkheads, decks or stringers, fit into or against the castings. These structural members, therefore, have stock added where they connect with cast- ing. This stock is burned off suitably by the shipfitter to make a good fit. Small local defects in large castings are repaired by chipping out and refilling with weld metal. Grinding wheels smooth up rough spots and improve the faying surfaces (surfaces of con- tact with other members).

Shell plating is fastened to the stern frame by welding, by riveting, or by tap rivets. Tap rivets are really bolts with countersunk heads, as shown in Fig. 161. The raised parts of tap rivets can be twisted off and chipped flush when they are tight.

Hawse pipes are cast in one, two, or three pieces. The pattern for a one-piece hawse pipe is tried in place on the ship before

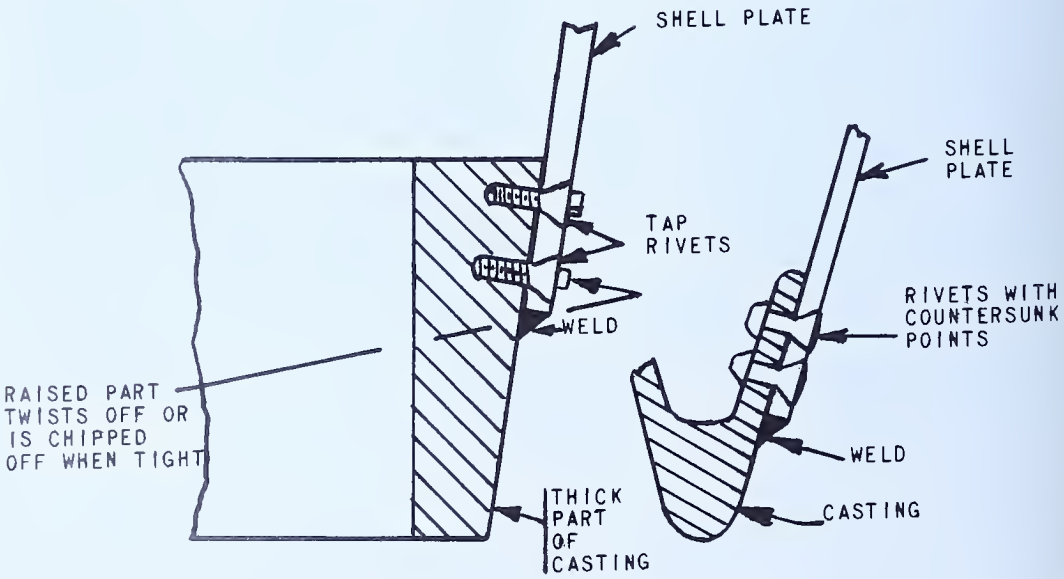


Fig. 161 -- Methods of Attaching Shell Plating to Castings

being sent to the foundry. Modern built-up hawse pipes are easier to fit and patterns for two or three-piece pipes need not be tried on the ship.

A shipfitter must see that the holes in deck and shell are properly burned out.

The smaller castings with which a shipfitter has to deal require accurate blue print reading to get them in the proper location, and careful leveling and setting of the casting or of the foundation which supports it (as in the case of chocks and fairleads).

Portlight frames are bronze castings which are fastened in place with brass screws. The important considerations here are proper location, fairing of the steel work before installing (to prevent cracking the glass when the frames are tightened) and protection of the glass from burning or welding sparks. The glass is coated with lacquer to shed the sparks.

Ordinary small cast fittings must be correctly located and fastened by the shipfitter if they come under the classification of hull work. Fittings not specifically located by a blue print usually are placed to suit the inspector representing the owners of the vessel.

Questions

1. What is a casting?
2. Why do large castings, even when made from the same pattern, sometimes vary in dimensions?
3. What are tap rivets?
4. What is a hawse pipe?

FOUNDATIONS

The main engines, boilers, pumps, fans and all other heavy machines, as well as most of the smaller rotary or reciprocating machinery, are mounted on foundations which carry and distribute the load. Heavy spare parts, such as cylinder liners, tailshafts, pistons, propellers, etc., are also fastened to foundations or "stowages."

Modern foundations usually are built of plates welded together. Old-time foundations were riveted. The present welding methods save weight and work, and eliminate the possibility of rivets loosening and working out owing to the vibration of an engine or motor.

Foundations should, whenever possible, be erected, fitted, and welded while the ship is yet on the shipway. Here levels and plumb bobs can be used. Practically all foundations require at least one surface either horizontal or vertical. When the ship is in the water, levels and plumb bobs are of no use, and leveling or setting must be done by measurement from previously set members, such as bulkheads, stanchions, and decks.

Foundations are, in general, built from blue prints in the shop, and are sent to the ship with an inch of extra stock on the

members which must be fitted to a deck or frame when leveling

The foundations for the main turbine and reduction gear o other main propulsive units are set by measurement from a previously determined centerline of the propeller shaft. It is ver

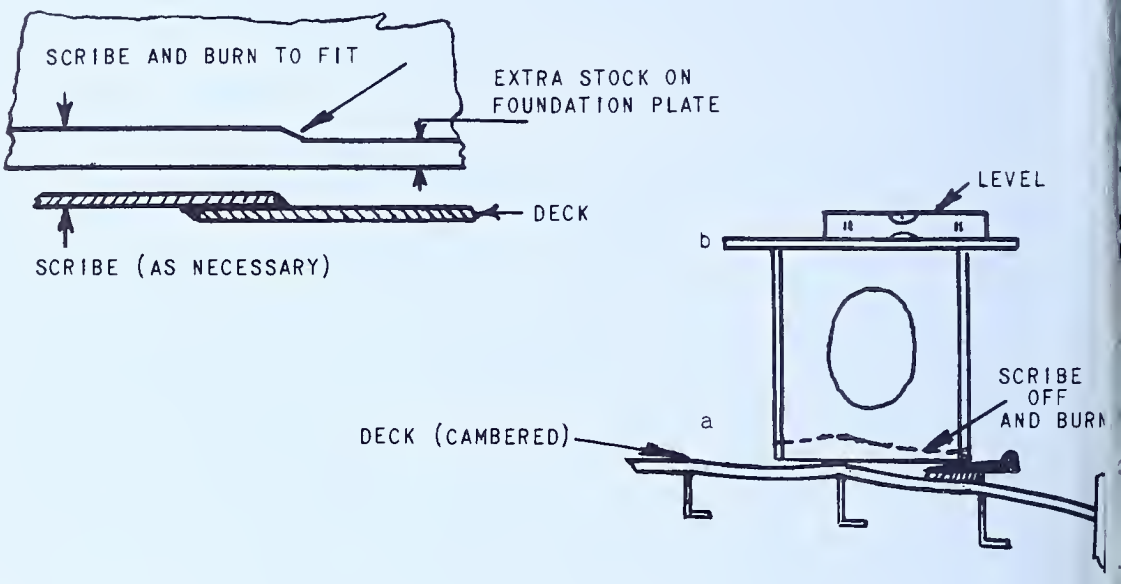


Fig. 162 -- Scribing and Setting Machinery Foundations

important that the propeller shafting, engines, etc., line up straight and true, to eliminate undue stresses and vibration when the vessel is underway. The centerline is usually "run in" by a surveyor and marked for measuring purposes by means of a taut piano wire.

How to Set a Foundation

PROCEDURE:

1. Block up the foundation, using wedges or other devices, until it is level, and in a position which will permit it to drop directly downward to the proper location and position when the bottom is scribed and burned.

   The foundation must be set correctly to longitudinal and transverse measurements.

2. Scribe the bottom of the foundation at the proper height above deck, raising or lowering the scribed line to fit any irregularities.

   Detailed instructions for scribing may be found on page 152, "Scribing Foundations for Burning." The correct height of the scribed line may be calculated from the dimensions given on the foundation drawing, and from related drawings.

3. Burn the bottom of the foundation along the scribed line.

4. Remove wedges, packing, and scrap from beneath the found-

ation, permitting the foundation to drop into position.

5. Check all position measurements of foundation. Also, see that the top surface is level.

6. Line and tack base of foundation to deck or other supporting member. The scribed-off surfaces are pulled tight with bolts and clips, if necessary, ready for tacking. The flat surface is checked again with level and declivity board, and if everything is satisfactory, the foundation is tacked.

7. Have foundation welded.

Scribing and Setting an Auxiliary Foundation

How to Lay Out and Build a Foundation

Cases often occur in which the shipfitter must take the drawings and lay out the steel, as well as assemble the foundations for welding. In Fig. 163, is illustrated the foundation for a fuel oil service pump.

Let us suppose that it must be laid out, assembled, fitted, and set by a shipfitter who will work from this sketch.

PROCEDURE:

1. Lay out the length and width of the piece "aa", Fig. 163, on a 3/4" steel plate.

2. Mark on plate "aa", location lines for the two plates "ad". These lines are 4" from the long edges of the piece "aa". The lines for the thickness are 1/2" further from the edges. (Actually, the center of the plate "aa" should be marked and center punched first, and all measurements taken or checked from this line). These markings must be placed on what will be the under side of plate "aa".

3. Mark on plate "aa", location lines for the transverse brackets "ac" and the flat bars "ab".

   These lines would be 6-1/2" from the shorter edges of the plate. (Thickness lines 7" from edges, since brackets are 1/2" thick). Plate "aa" then appears as in Fig. 164.

4. Lay out the two pieces "ad" on a 1/2" plate of sufficient size.

   These plates will each be 46-3/4" long, as shown in the drawing. The problem is, therefore, to find the height of these two plates. By subtracting the liner thickness and thickness of plate "aa", and top of plate "ad" is found to be 10"—2 3/4" above the base line. It is now necessary to get related or

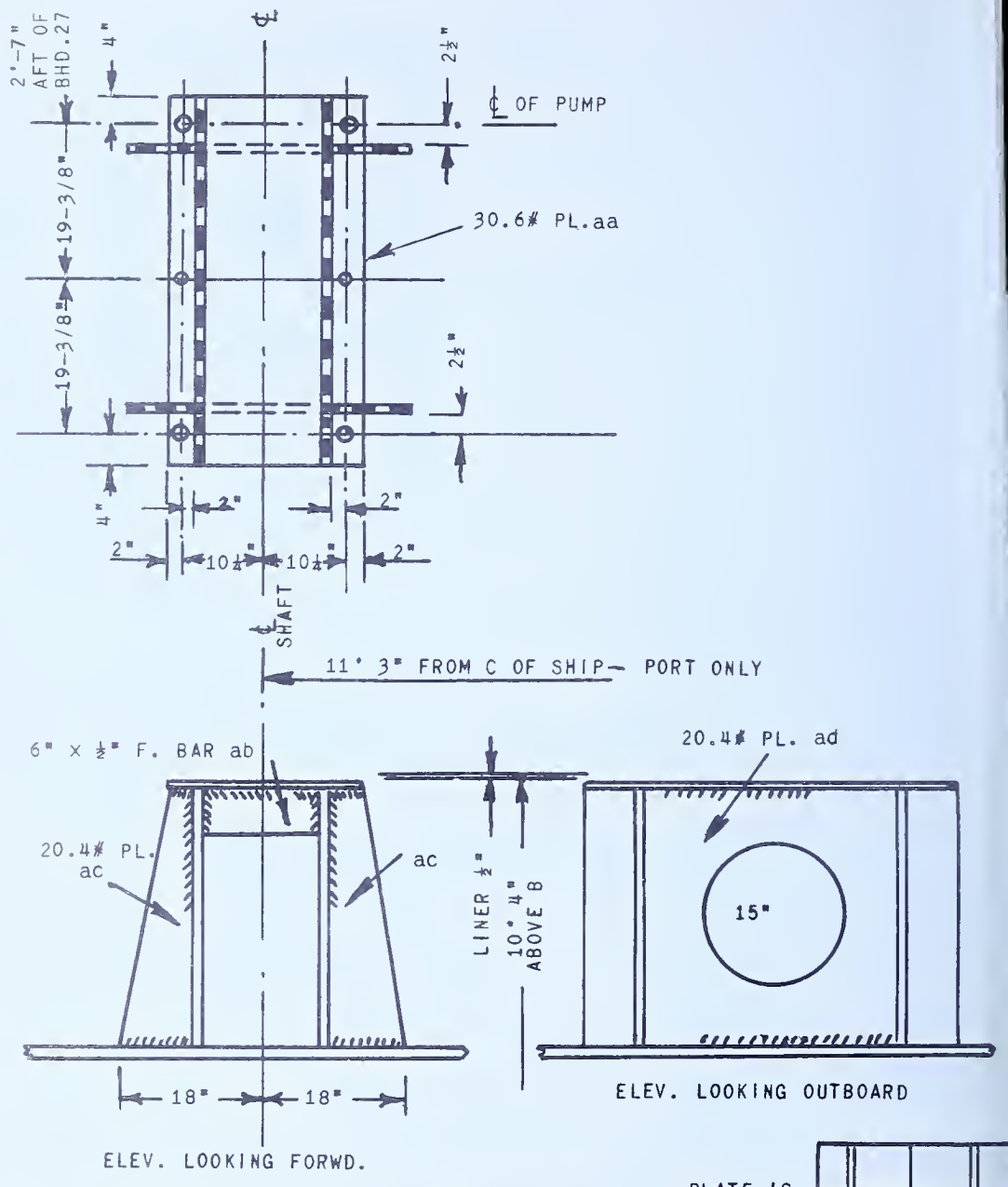


Fig. 163--Fuel Oil Service Pump Foundation

"reference" drawings to find the height from the base line to the top of the inner bottom plate.

The drawing of the transverse framing or bottom floors, in way of the foundation, will give the height from the base line to the moulded line (under side) of the innerbottom. Suppose, in this case, that this moulded height is 7'-6". The drawing of the innerbottom plating (tank top) will show the thickness of the plate or

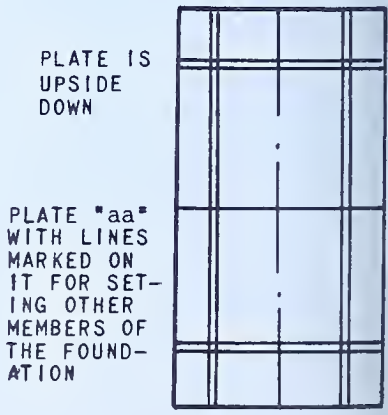


Fig. 164--Lines Marked on Top Plate of Foundation

plates on which the foundation is to set. Suppose that the plating is flush welded and 3/4" thick. The height from the base line to the top of the innerbottom plating is then 7'–6 3/4". Subtracting this from 10'–2 3/4" gives the height of plate "ad" as 2'–8".

However, to be safe, it is customary to add 1" of stock at the bottom of the plates to allow for irregularities in the tank top. Plates "ad" are, therefore, made 46–3/4" by 33". The lightening hole is laid out in the center of the final plate or 16" below the top and 23 3/8" from each end.

5. Lay out the four brackets "ac" on 1/2" plate (20.4# Pl.).

Use the dimensions given in the drawing, together with a height of 32" (as calculated in step "4" for piece "ad") to give the bracket the correct taper. The 1" stock is then added at the bottom.

6. Cut the two pieces of 1/2" x 6" flat bar "ab", each 15 1/2" long.

7. Mark on plates "ad", location lines for setting the pieces "ac" and "ab".

8. Assemble the foundation upside down on a flat surface.

First dog down plate "aa" on a flat surface. The previously marked location lines must be *upward*. Assemble and tack, in an upside down position, the remaining members of the foundation. A foundation is built in this manner so that the top plate will remain straight and not be twisted (since this is where the machinery will contact the hull). Also, this plate usually is the only member to which all the others are to be welded.

9. Have foundation welded and sent to the ship.

10. Locate foundation in its correct position on the ship.

Blue prints for foundations, almost invariably give the location in reference to the base line, centerline, and a frame line of the vessel.

11. Level, scribe, burn and set foundation (as previously explained). Note: When a number of duplicate foundations must be made, it is advisable to make wood, strawboard, or red paper templates to speed the laying out process.

Questions

1. Why are machinery foundations needed?
2. Why is extra stock left on the bottom of most foundations?
3. What is meant by "scribing" a foundation?
4. Why must foundations be checked with a level *after* they are tack welded?
5. How is the height of a foundation side plate determined when not specified directly on the drawing?

SCRIBING FOUNDATIONS FOR BURNING

When scribing the foundation plates for burning, the top pla is often raised far enough from the required position so that even measurement, (2" for example), can be used for marking. A th piece of metal should be used as a spacer, as shown in Fig. 1 (B). This is especially necessary on large foundations, owing the tendency of a wooden block to wear down when rubbed over stee The thin spacer also provides for accuracy at deck irregularitie as illustrated at (A) and (B).

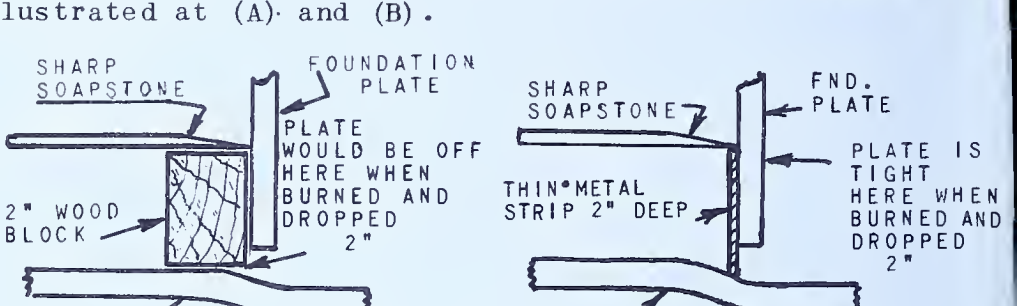


Fig. 165 -- Scribing Foundation Plate

SCRIBING AGAINST SLOPING MEMBERS

When the foundation plate is to be welded along a sloping shel plate as is shown in Fig. 166, it should be marked on the tigh or closed bevel side and burned off square.

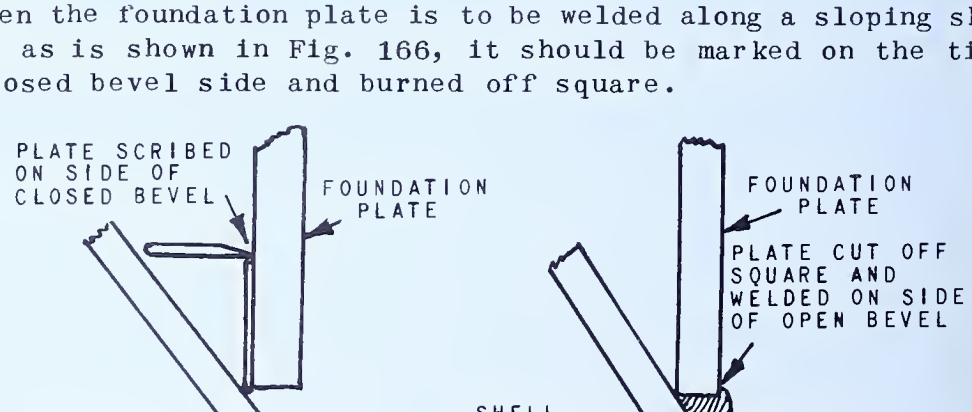


Fig. 166 -- Fitting Foundation to Sloping Shell Plate

The weld should be made on the opposite or open bevel side, as at (B) in Fig. 166. If necessary, a chip can be taken off the corner to allow a better weld. Fig. 167 shows a foundation plate to be scribed in a transverse direction along a sloping shell plate. Here it must be remembered that the foundation, when burned, must drop straight down into place.

Along the horizontal tank top, the metal spacer can be used for scribing. At the sloping shell plate, measurements must be taken vertically as illustrated, and a line faired through the spots thus

marked as a guide when burning. If the 2" spacer were used at the sloping shell, the 2 inches would be perpendicular to the shell. This would make the *vertical measurement more than 2 inches* and the foundation plate would not fit tightly. (The steeper the slope the larger this opening would be). This is a very important consideration in the setting of foundations.

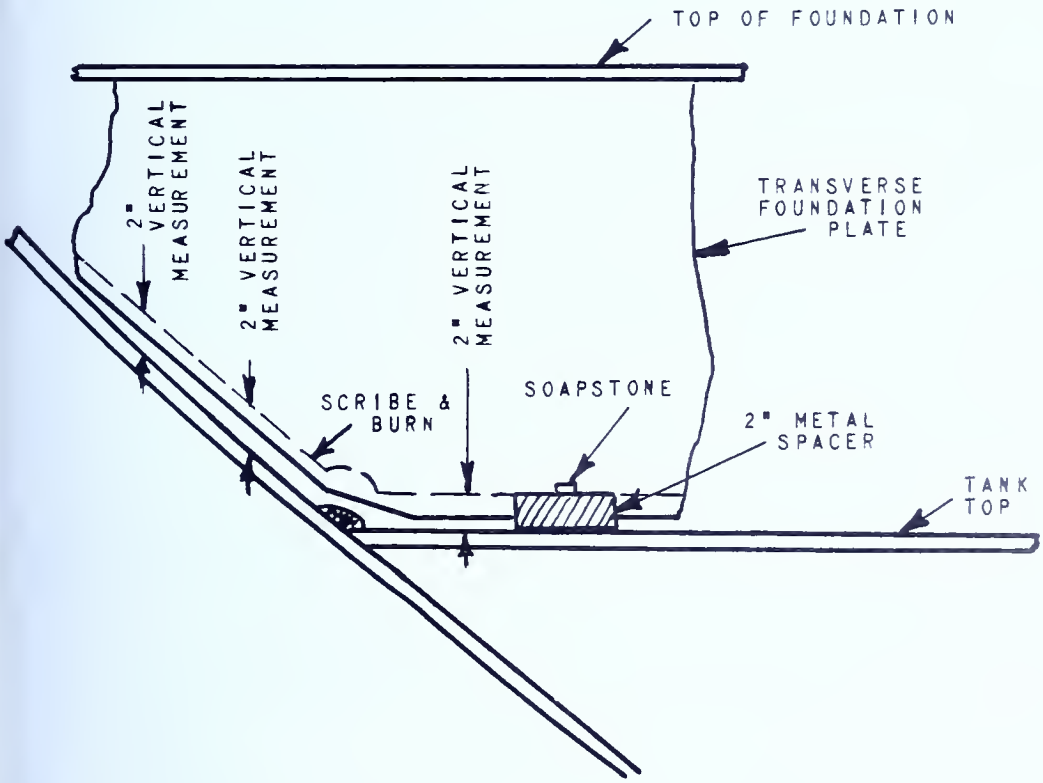


Fig. 167 -- Scribing Transverse Foundation Plate at Sloping Shell

Questions

1. Why is a thin metal spacer preferred for scribing machinery foundations?
2. What special precautions are taken when scribing a foundation against a sloping member?

SETTING FOUNDATIONS BY MEASUREMENT

Many instances occur where foundations cannot be set with level and declivity board, even on the shipways. These must be set by measurement, as must all foundations installed after launching. One example of the former is a spare tailshaft foundation at the after end of a tanker's engine room.

This foundation generally is made in two or three parts, and the center line of the shaft would not be parallel to either a

frame line or the center line. This condition is illustrated in Fig. 168. The spare tailshaft is shown stowed against the side shell, with its center line level. The foundations must be set perpendicular to this centerline, and high enough to support the shaft properly.

To set the foundations "c" and "d", a chalk line or wire is stretched from point "a" to point "b". This line represents the center line of the shaft. Points "a" and "b" are determined by measuring the proper height above the base line and their respective distances from the center line at given frame lines as found on the drawing. The line can be fastened at "a" and "b" to web frames or any permanent or temporary support which may be handy. Sometimes a scrap angle or flat bar is welded to a frame to permit fastening the string. The foundations "c" and "d" may then be properly squared.

Questions

1. Under what conditions must foundations be leveled by measurement without use of level?
2. Suppose that a foundation is to be welded to a bulkhead, and must be 17'-6" above the base line. How can the proper location be determined if the base line is covered with three feet of water?

LAYING OUT PLATES FOR SHEARING

When several members are to be cut from a single large plate, they should be laid out in such a manner that as many cuts as possible may be made with the shears. For example, in Fig. 169 are illustrated two methods of laying out several pieces to be cut from a plate.

At (A), the long transverse cuts across the plate can be made first in the gate shears, the pieces then being separated and trimmed. In this example *all cuts are made with the gate shears.* There is a limit to the length of cut which can be made in the gate shears. For this reason the plate should be laid out as at (A), permitting the transverse cuts to be made full length across the plate in a straight line. If the transverse cuts were offset or irregular as at (B), the plate would have to be burned (along the cut "xy") before the sections could be sheared.

It is possible to cut a narrow margin from a long plate, using a series of bites with the scissor shears. However, too much distortion would be caused by trying to shear the plate through the center in this manner. Therefore, the plate should be laid out so as to permit a maximum number of straight transverse cuts.

Suppose that the members to be laid out are so shaped that the plate must be burned before shearing. (This sometimes is necessary

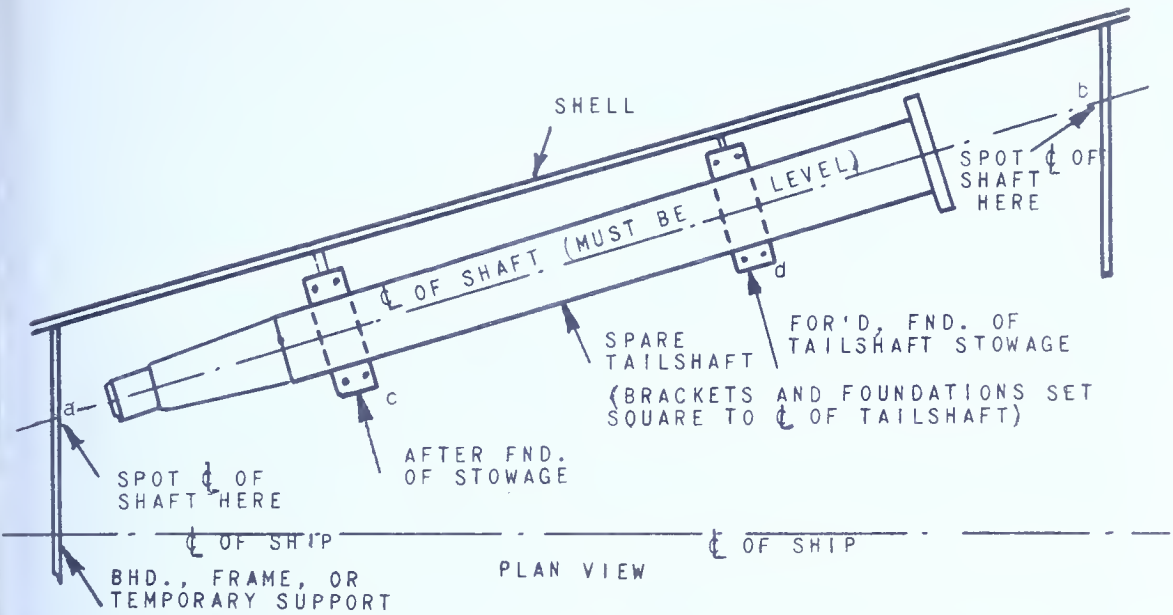


Fig. 168 -- Stowage for Spare Tailshaft

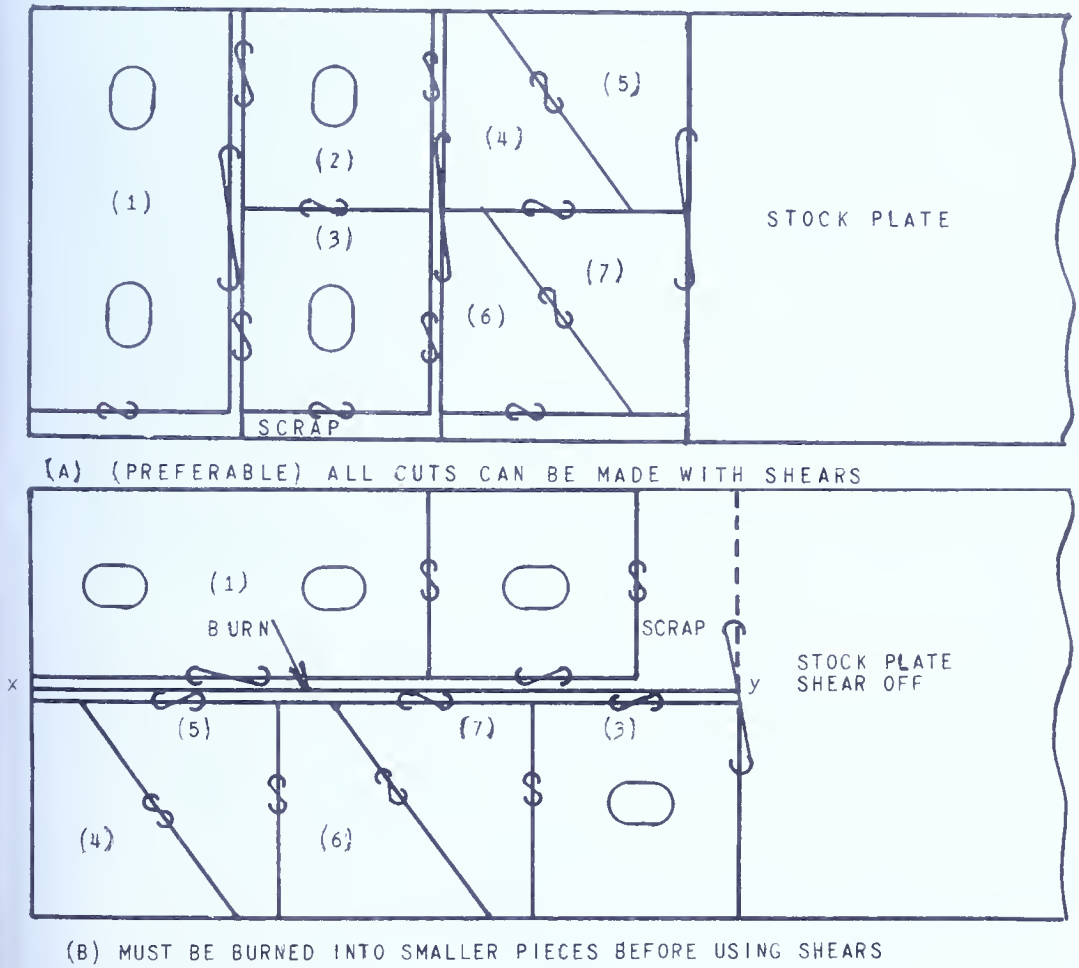


Fig. 169 -- Laying Out Plate for Shearing

to prevent an overlarge amount of scrap). The cut made by the torch is at least 1/8" wide, and is rather rough, unless special care is taken. For this reason, the members 3, 4, 5, 6 and 7 in (B) in Fig. 170 have been laid out so that their lower edges lie along the bottom edge of the plate. This leaves the scrap in the middle of the plate where the burning cut is to be made. This may then be a rough cut down the middle of the scrap. All pieces may then be sheared and the rough-burned scrap edges taken off (all with the gate shears).

It should be noted that the scissors shears are used to reduce the width of flanges on long angles (when this is required). The gate shears are used to trim the flanges of short angles or clips. In laying out for shearing a plate which must afterward be planed, it is usual to leave 1/4" of stock at each edge requiring planing.

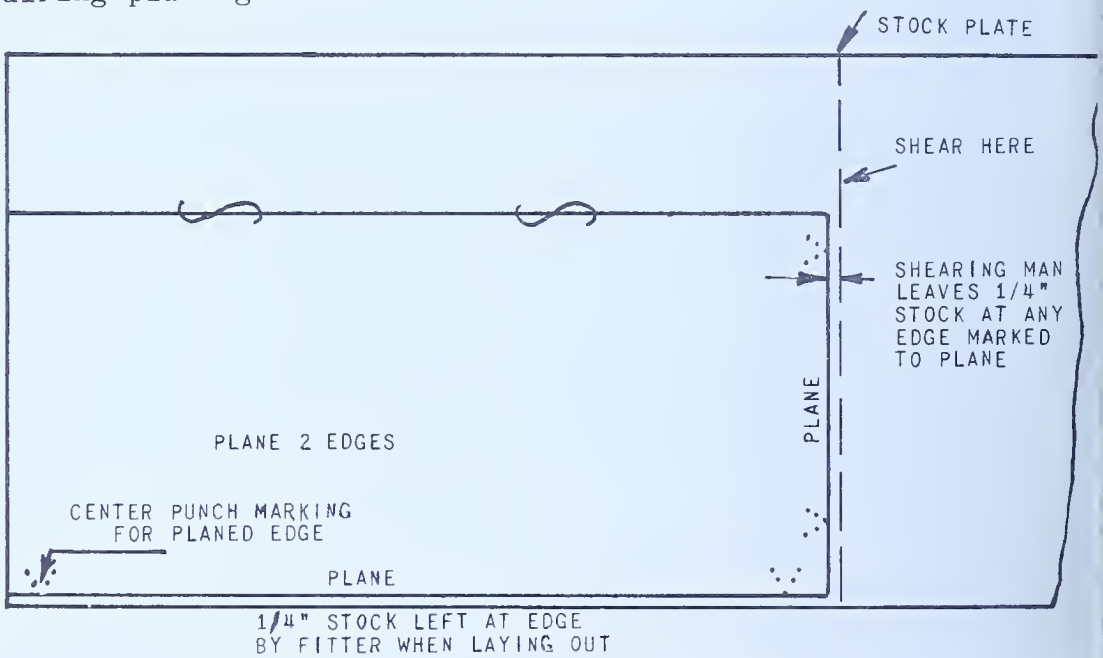

STOCK PLATE
SHEAR HERE
SHEARING MAN LEAVES 1/4" STOCK AT ANY EDGE MARKED TO PLANE
PLANE
PLANE 2 EDGES
CENTER PUNCH MARKING FOR PLANED EDGE
PLANE
1/4" STOCK LEFT AT EDGE BY FITTER WHEN LAYING OUT

Fig. 170 -- Shearing and Planing Layout

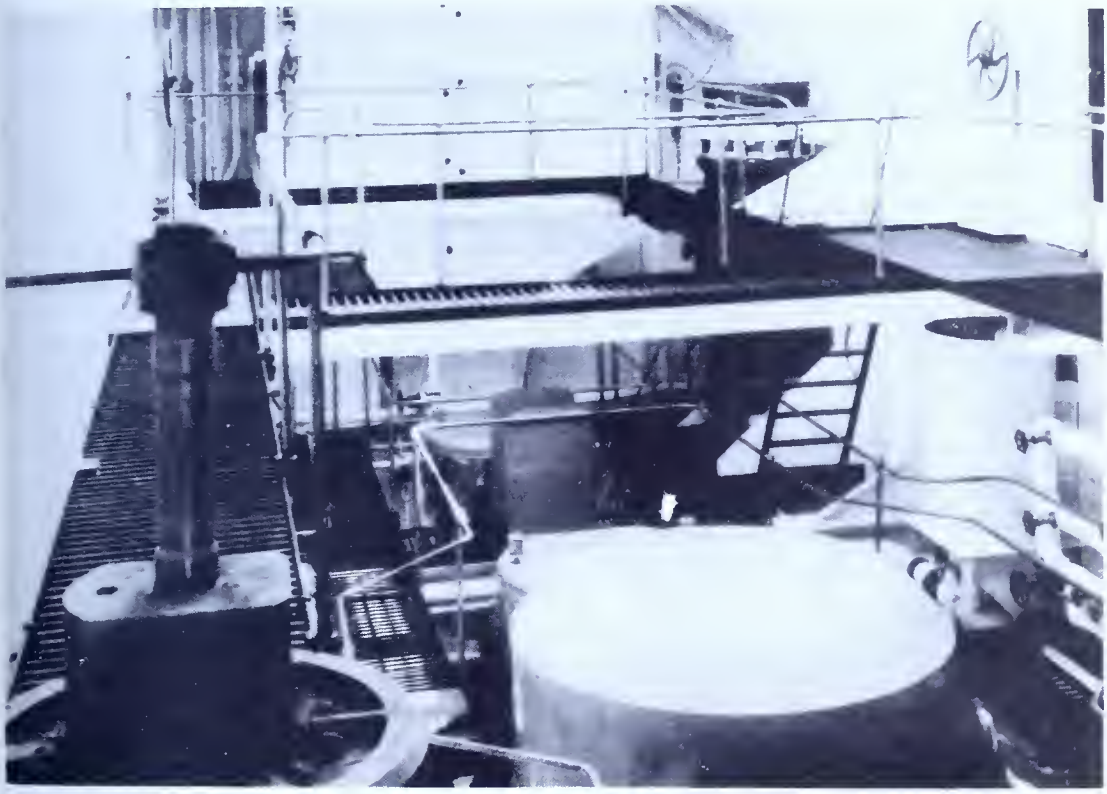
Fig. 170 illustrates a plate which has been laid out for shearing and planing. The lower and right-hand edges are to be planed, while the top and left end are merely to be sheared. The bottom edge has been marked 1/4" from the edge of the stock plate by the shipfitter. The right-hand edge has been marked "plane", which directs the shearing man to leave 1/4" stock outside the line.

Questions

1. What precautions should be taken when laying out plates for shearing?
2. Why must large plates sometimes be burned before they are sheared?
3. Why is 1/4" stock left on a plate edge which is to be planed?

FITTING ENGINE ROOM GRATING

In the engine room and pump rooms of a vessel are several levels of grating for access to different parts of the engines and to all other machinery. Ladders are fitted between the various grating levels and to decks, flats, and engine room floor. This floor is several feet above the tank top and usually is composed of plates which have a non-skid raised tread (diamond plates). The majority of these plates and grating sections must be made portable; that is, they are fastened in place with nuts and bolts rather than being welded or riveted. (All piping and engine parts must be accessible and removable.)



View Showing Engine Room Grating

Floor plates, ladders and gratings usually are made by shipfitters. Blue prints are made showing the expected location, shape, and size of each piece of grating, although in the average ship many changes are made in location of pipes and machinery during construction, and the grating must be changed to suit. All grating work is checked by means of measurements taken directly from the ship. Grating, whenever possible, is arranged so that the cross bars in one section line up with the cross bars in the adjacent section. This, of course, improves the appearance. Cross bars are spaced on an average of 2-3/8", unless otherwise specified, although the bars may be closer together or farther apart locally to bring the joints or ends to the proper location.

Fig. 171 illustrates a typical splice between two sections of grating. Flat bars are bolted across the ends of the grating side bars and fastened with two bolts to each side bar. This splice is

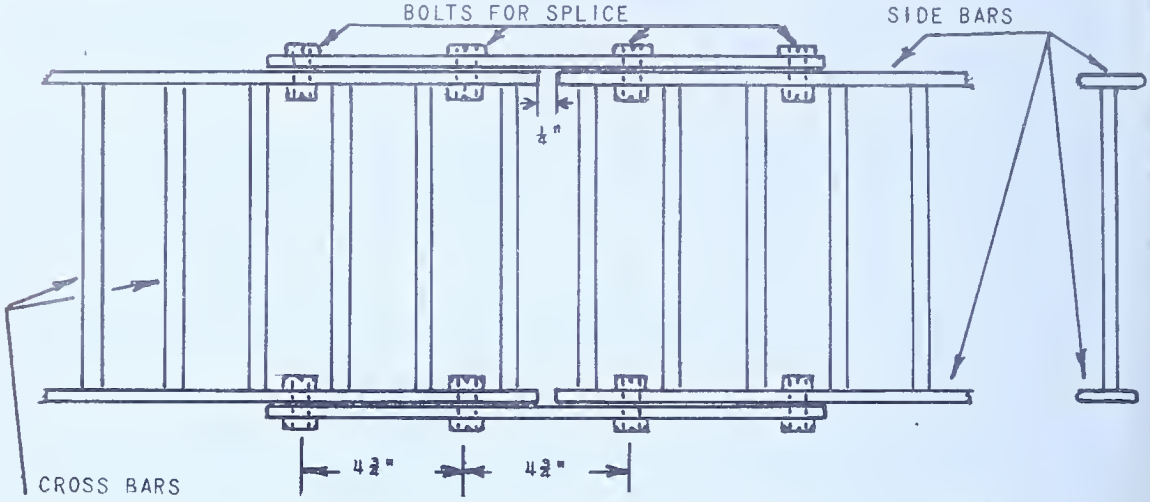


Fig. 171 -- Grating Splice Used Where No Support is Under Joint.

strong and may be used even when there is no support directly under the joint. A clearance of 1/4" is always kept between two grating sections as shown. This is done by cutting back each end of each side bar 1/8" from the specified butt.

The cross bars or "spars" are fastened to the side bars (runners) by actually "driving" or upsetting the ends of the cross-bars. This is done cold, using a die held in a chipping gun. Fig. 172 shows how the spar ends are tightly upset in the runner holes.

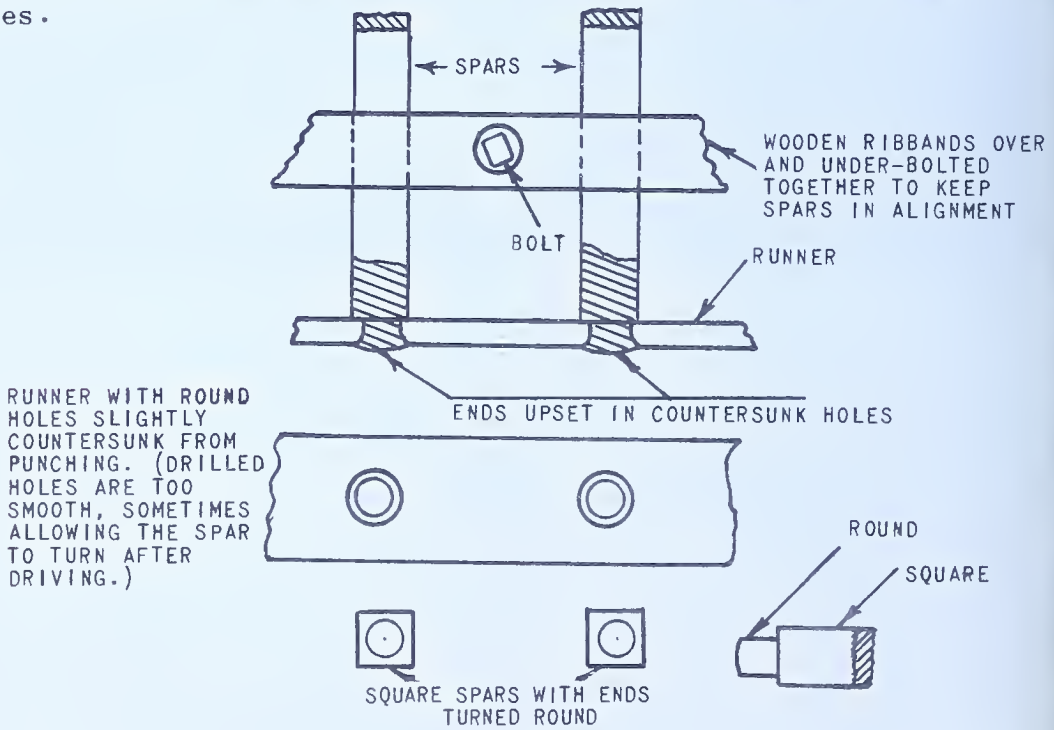

SPARS
WOODEN RIBBANDS OVER AND UNDER-BOLTED TOGETHER TO KEEP SPARS IN ALIGNMENT
BOLT
RUNNER
ENDS UPSET IN COUNTERSUNK HOLES
RUNNER WITH ROUND HOLES SLIGHTLY COUNTERSUNK FROM PUNCHING. (DRILLED HOLES ARE TOO SMOOTH, SOMETIMES ALLOWING THE SPAR TO TURN AFTER DRIVING.)
ROUND
SQUARE
SQUARE SPARS WITH ENDS TURNED ROUND

Fig. 172 -- Fastening Spars to Runners

When a grating section is being assembled, the spars are kept in alignment with wooden ribbands which are bolted together through the grating, thus preventing the spars from turning.

In fitting gratings around pipes or pieces of machinery a clearance always is maintained, except where such machinery helps support the grating.

Very few shaped templates are made for grating. It is customary to make the grating in rectangular sections and cut the sections on the ship for fitting around a pipe or other obstruction. Fig. 173 shows how this is done. Two steel straps with holes are bolted tightly against the spars in way of the pipe to keep them in alignment while cutting and refitting the runner. The spars are cut back and a piece of the runner removed as illustrated, after which the flat bar stock, similar to the runner, is fitted and welded in place as shown. The bolted straps are then removed, leaving the grating ready for installation.

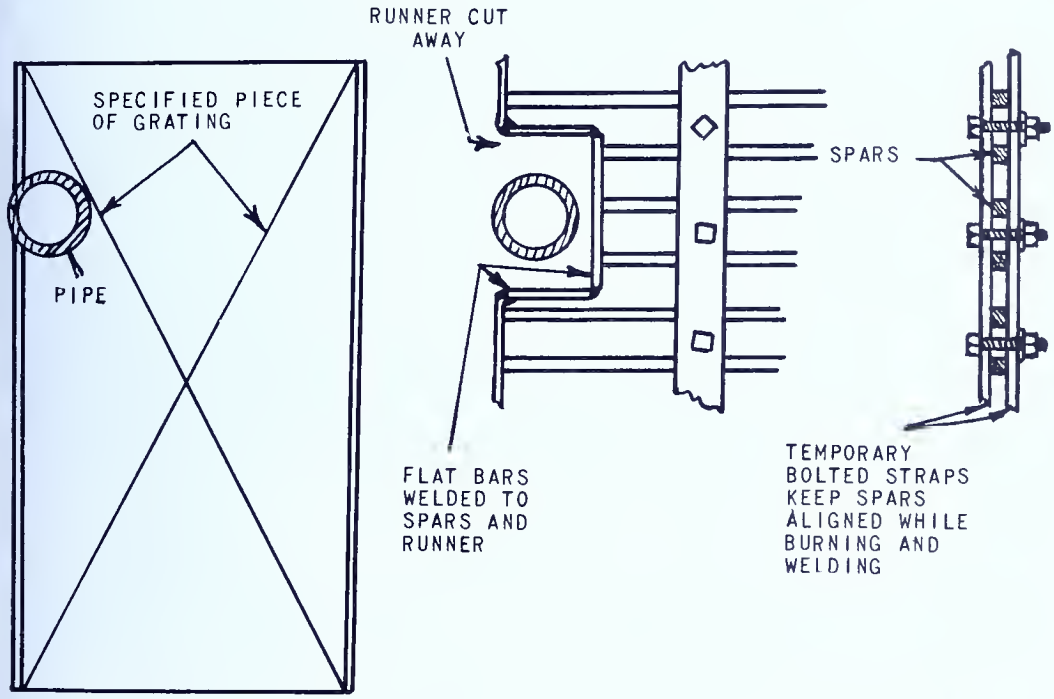

RUNNER CUT AWAY
SPECIFIED PIECE OF GRATING
PIPE
SPARS
FLAT BARS WELDED TO SPARS AND RUNNER
TEMPORARY BOLTED STRAPS KEEP SPARS ALIGNED WHILE BURNING AND WELDING

Fig. 173 -- Fitting Section of Grating Around a Pipe

TEMPLATES FOR GRATING

The making of templates for grating is a job requiring accurate reading of the blue print and a certain amount of common sense in changing details to suit conditions.

In making templates for grating sections, it is customary to use flat wooden battens with the locations of the spars marked on the side, as well as the location of holes necessary for splices, etc. Fig. 174 shows two typical templates for sections of engine room grating. (A rough plan view also is shown to illustrate the general appearance of the grating made from each template.)

The templates are about 4" wide, with lines crossing to show the location of the spars. The bottom of the template represents the near side-bar (that is the near runner) while the top represents the far side. The meaning of the markings can be seen by referring to the plan view. In the template at (A), the left end shows a cross-hatched section and is marked "Box". This refers to the grating section. (The other end is similar.) An 11/16" hole is punched at each end of the runner on the far side. The (inside) width of the grating is given as 21". Sizes of runners and spars are marked, as well as the charge or drawing number (195-844). The location is also denoted. ER means engine room; Upper Eng. means upper grating at the engine. "1 Gra. off" means that one piece of grating is to be made from this template.

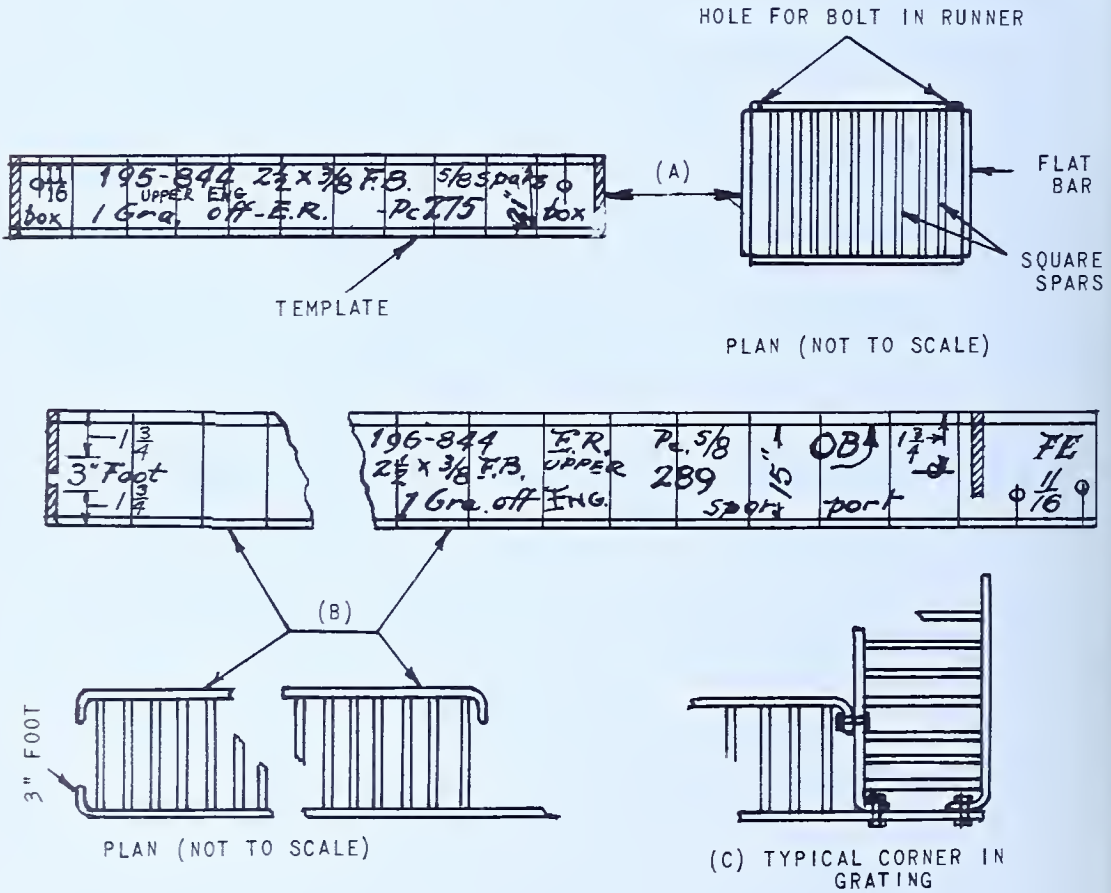


Fig. 174 -- Grating Templates

The template at (B) is for a longer piece of grating, the runners of which have "feet" or flanges at the left end with holes for fastening with bolts to a support or to a transverse grating section. (The gauge of these holes is 1-3/4".) The right end has a foot at the far runner and a straight extended end on the near runner. These fasten to another piece of grating to form a corner in the walkway as illustrated at (C) in Fig. 174.

SUPPORTS FOR GRATING

Grating is supported, when possible, by members of the ship or engine structure. Pads or clips are welded to take bolts as illustrated at (A) in Fig. 175. At (B) the grating is shown fastened to the pad with a hook bolt.

Other supports for grating are arranged largely according to the judgment of the fitter on the job. Angle bars are used for

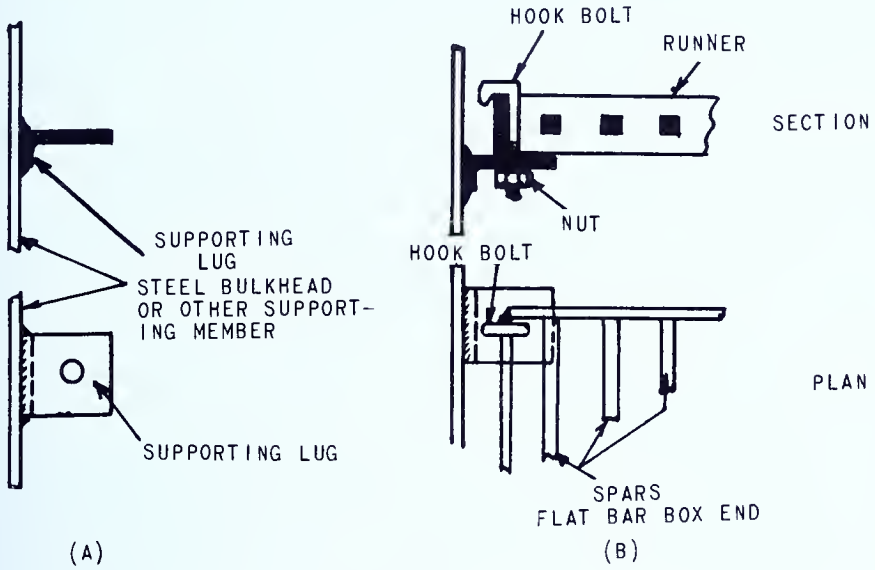


Fig. 175 -- Clip for Grating Support

struts and ties, as well as for removable beams under long spans of grating. All grating supports are put in place on the ship before the grating sections are installed. This is a safer and simpler method than would be the procedure of using temporary ropes or wires as fastenings while the permanent supports were being erected.

Questions

1. What are spars? Runners?
2. How may two grating sections be spliced together?
3. How are spars fastened to runners?
4. How is grating supported?

FITTING ENGINE ROOM FLOOR PLATES

Floor plates in the engine room are made of skid-proof plates, as previously mentioned. These plates are smooth on one side and rough on the top, in a pattern of raised treads of diamond shape. Diamond plates are delivered to the shipyard in the standard size of 2±0" x 4±0". Many of these must be cut to fit around obstructions, such as machinery, pipes, and foundations.

How to Fit Engine Room Floor Plates

PROCEDURE:

1. Establish a longitudinal reference line parallel to the center line of the ship (see Fig. 176).

   The centerline of the ship may be found center punched c bulkheads, tank top, foundations, or some other member. If n marks can be found, the centerline may be found by measuremer from members whose distances off the centerline are known

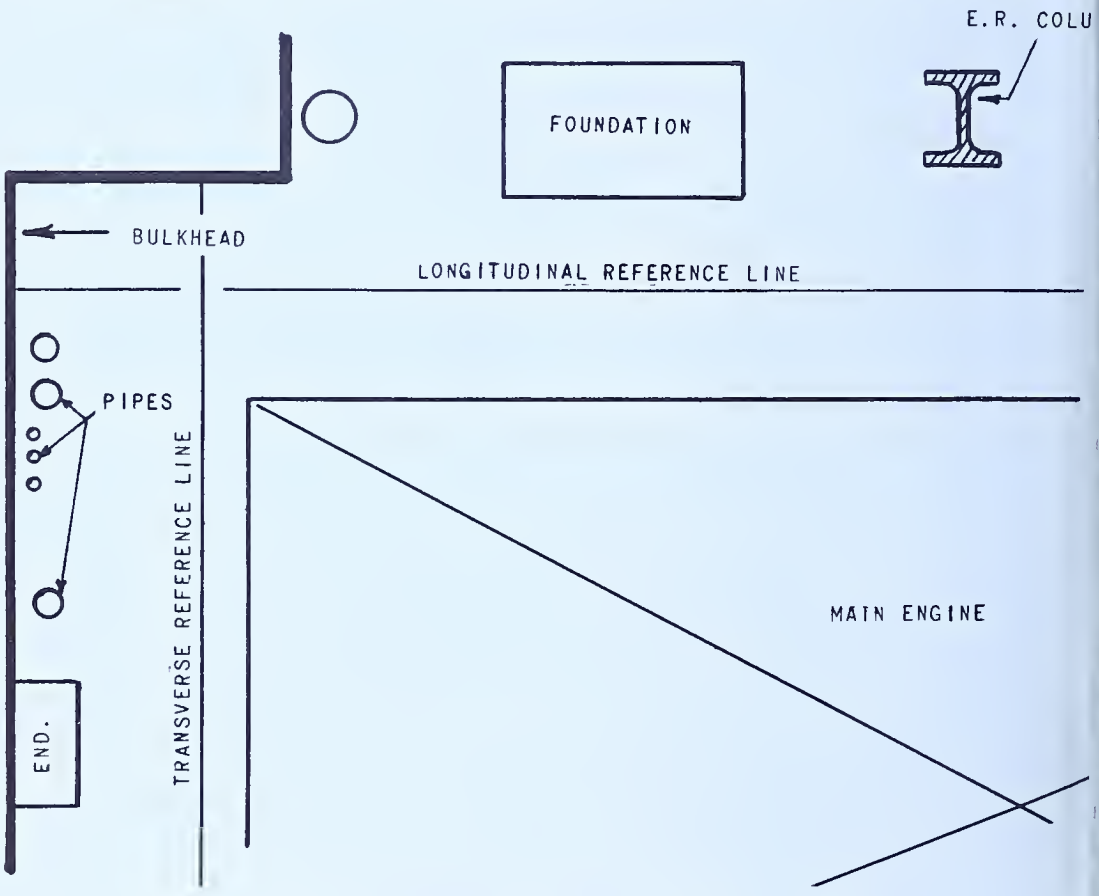


Fig. 176 -- Reference Lines for Floor Plating

2. Establish a transverse reference line. This line is perpendic ular to the longitudinal reference line.

   Both longitudinal and transverse reference lines are indi cated by stretching a wire or chalk line between measure points.

3. Take measurements in the engine room from these reference lin to all machinery, pipes, foundations, and other obstructio in the plane (surface) of the floor plates.

4. Reproduce the two perpendicular reference lines by marking a loft floor, or other smooth wooden floor.

5. Using the measurements previously taken, lay out on the floor the entire surface or the section under consideration.

6. Using the above layout, make the templates for the floor plates.

Templates may properly be fitted around pipes, corners, etc., working entirely from the layout on the floor.

The various sections of plating are all fastened to their supporting angles with machine screws, as shown in Fig. 177. Every butt has such an angle under it for support and fastening, except

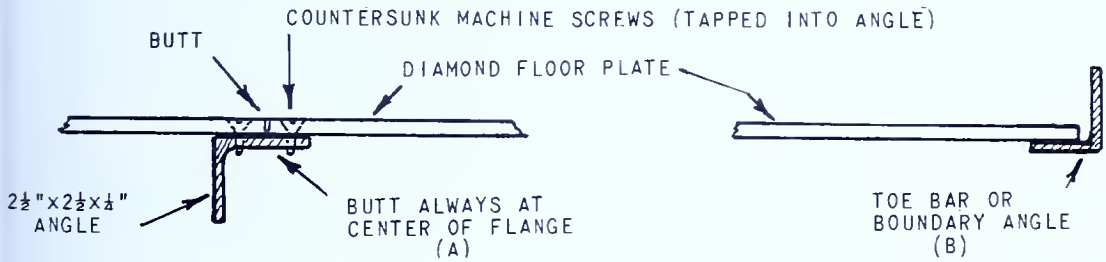

COUNTERSUNK MACHINE SCREWS (TAPPED INTO ANGLE)
BUTT
DIAMOND FLOOR PLATE
2½"x2½x¼" ANGLE
BUTT ALWAYS AT CENTER OF FLANGE (A)
TOE BAR OR BOUNDARY ANGLE (B)

Fig. 177 -- Floor Plate Support and Boundary

where some member of the hull structure happens to be in position to carry the butt. Fig. 177 (B) shows the toe bar or boundary angle which is fitted at the edge of the floor plates around pipes, or adjacent to bulkheads. This forms a vertical flange to prevent objects from rolling off the floor plates and into the space above the tank top. The heel of the toe bar is generally kept away from the bulkhead a standard distance of 1½". Floor plates usually are supported by 2½" x 2½" angles in general, although larger angles are occasionally used over long spans. The angles are supported every 4 feet on straightway runs.

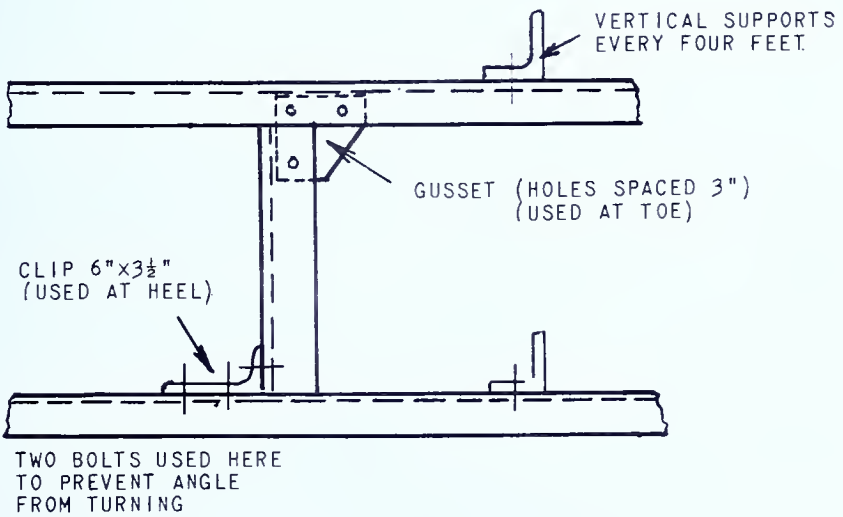

VERTICAL SUPPORTS EVERY FOUR FEET
GUSSET (HOLES SPACED 3") (USED AT TOE)
CLIP 6"x3½" (USED AT HEEL)
TWO BOLTS USED HERE TO PREVENT ANGLE FROM TURNING

Fig. 178 -- Floor Plate Supports

Figure 178 illustrates the standard gusset plates and clips used for connections of floor plate supporting angles. The gusset plate connects two flanges in the same plane, as when one angle butts against the toe of another. The 6" x 3½" clip connects two flanges at right angles, as when one angle butts against the heel of another. These fastenings can be made up in large quantities and widely used. In the installation of floor plates, as well as of gratings, the supports must be arranged to suit local conditions, while following the blue prints as far as is practicable. (Supporting angles usually heel forward or inboard.)

When installing floor plates it is necessary to check the butts, making sure they are parallel to either the longitudinal or the transverse reference lines. When a large opening is left which will subsequently be covered with floor plates the butts at the extremities of the opening must be set to the proper distance by regulating the other plates. The adjacent plates must then be screwed down tight to hold this measurement until the missing plates can be installed. This will assure a good fit for the plates.

Questions

1. What is the difference between "floors" and engine room "floor plates"?
2. Why is it necessary to establish reference lines at right angles to each other when lifting floor plates?
3. What is used to support floor plating?

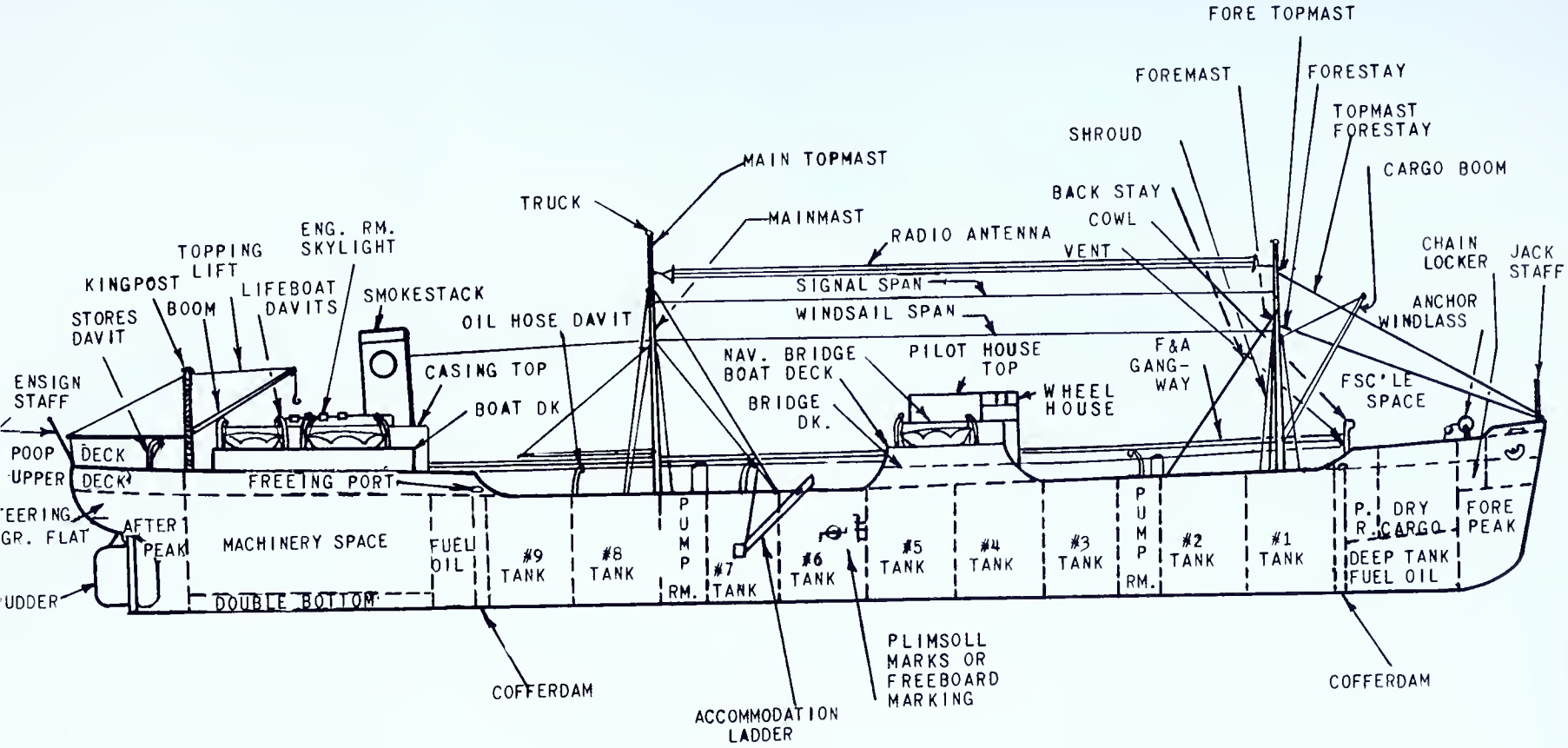


Fig. 179 -- Profile of a Tanker

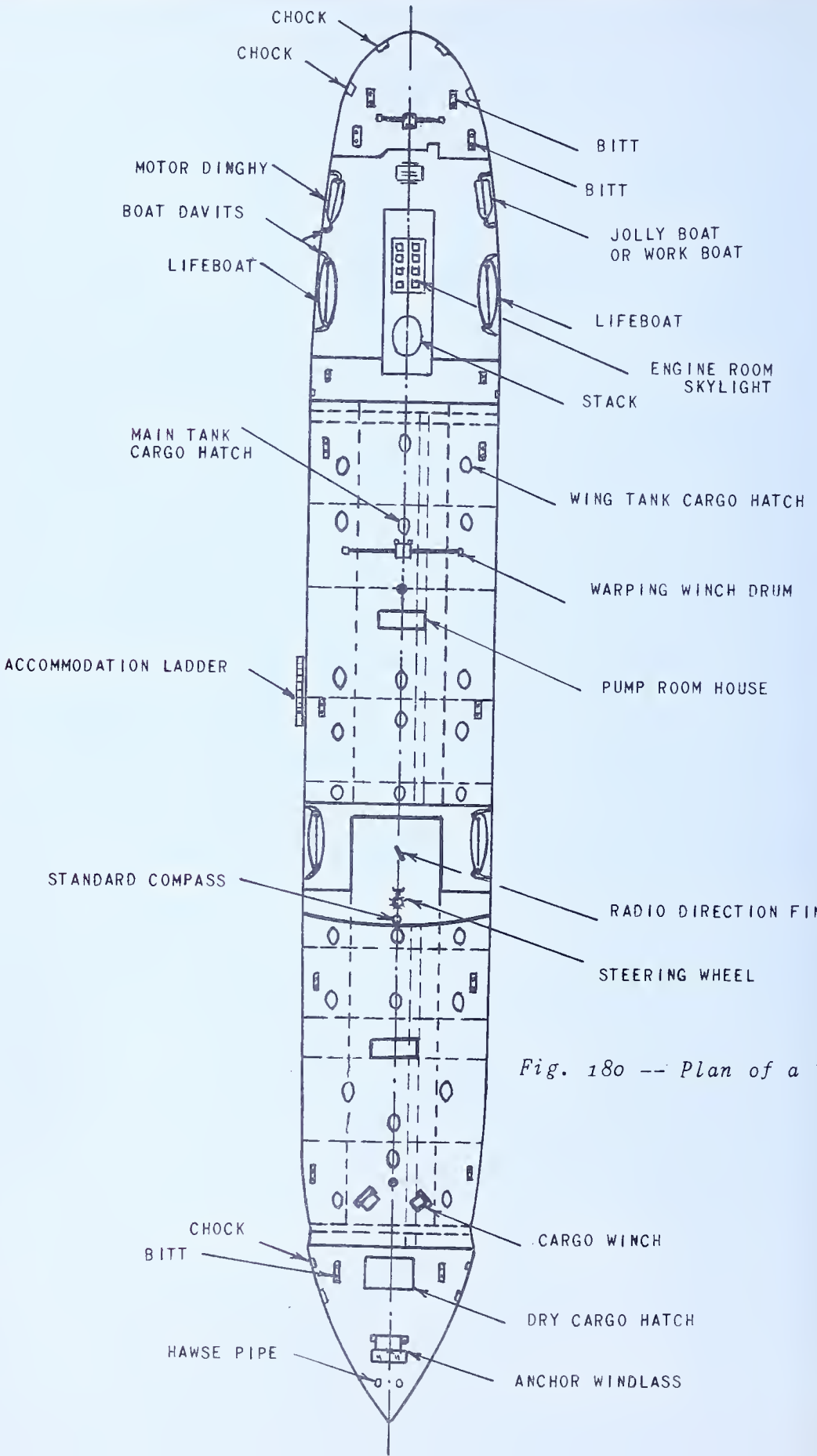


Fig. 180 -- Plan of a Tank

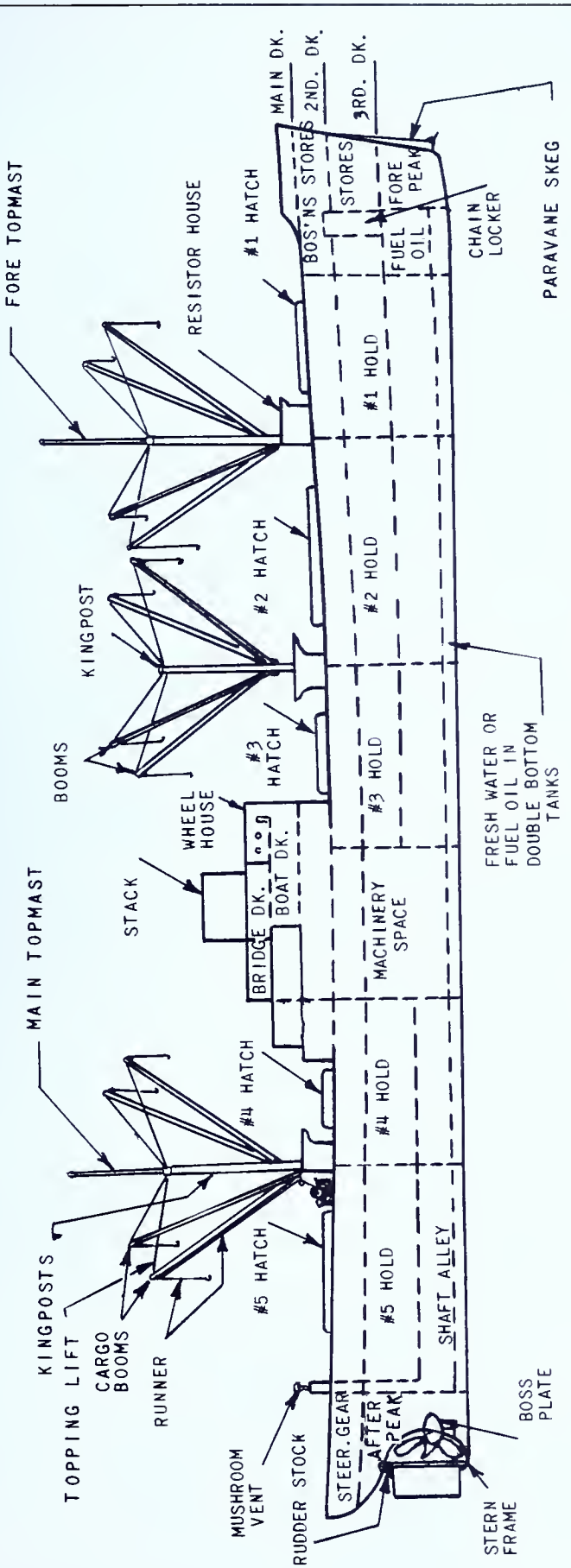


Fig. 181 -- Profile of a Cargo Ship

PART VIII

Miscellaneous Hull Fittings

CHARACTERISTICS OF TANKER AND CARGO VESSELS

Figures 179 and 180 illustrate the general appearance of a *tanker* in profile and in plan view, as well as the location (roughly) of many of the fittings and gear involved in handling the vessel and her cargo. Fig. 181 shows the different appearance and arrangement of a *freighter*. The meaning of many of the common shipbuilding terms may be understood by studying these sketches.

Note that the tanker has a fore and aft gangway from forecastle to bridge and from bridge to poop. This is necessary on account of the small amount of freeboard in a loaded tankship. Waves often break over the deck at sea. The innerbottom of a tanker usually extends only under the engine room, while in a freighter, the double bottom extends throughout the holds.

FITTING AIRPORTS

Shipfitters must install all airports in the hull plating. This job includes laying out the holes in the steel for burning and drilling; also, setting, puttying, and bolting up the frames so that the airport will be watertight.

In setting a circle torch to burn an airport hole in the hull the radius of the torch is made equal to that of the spigot.

The width of the cut made by the torch then increases the hole diameter 1/8", thus maintaining the required 1/16"clearance around the spigot.

After burning out several experimental holes in scrap plate the fitter should check the hole diameter, since the radius rod will expand from the heat, and in turn, will increase the diameter of the hole. As previously mentioned, measurements must be taken parallel to the centerline and parallel to the base line, unless otherwise specified. The hull form should be fair before the airport holes are burned, and checked again for fairness before the frames are installed. Generally the

Airports With Dead Covers

airport frames are sent to the ship and installed without glass or deadlights. Glass is not installed until surrounding work is advanced far enough so that damage will not result from welding or burning sparks. All parts of each airport must be stenciled before they are taken apart, to make sure that each light and deadlight is eventually put back on the correct frame.

The frames are set in putty with the hinge lugs at the top as illustrated in Fig. 182, unless otherwise specified. Because the

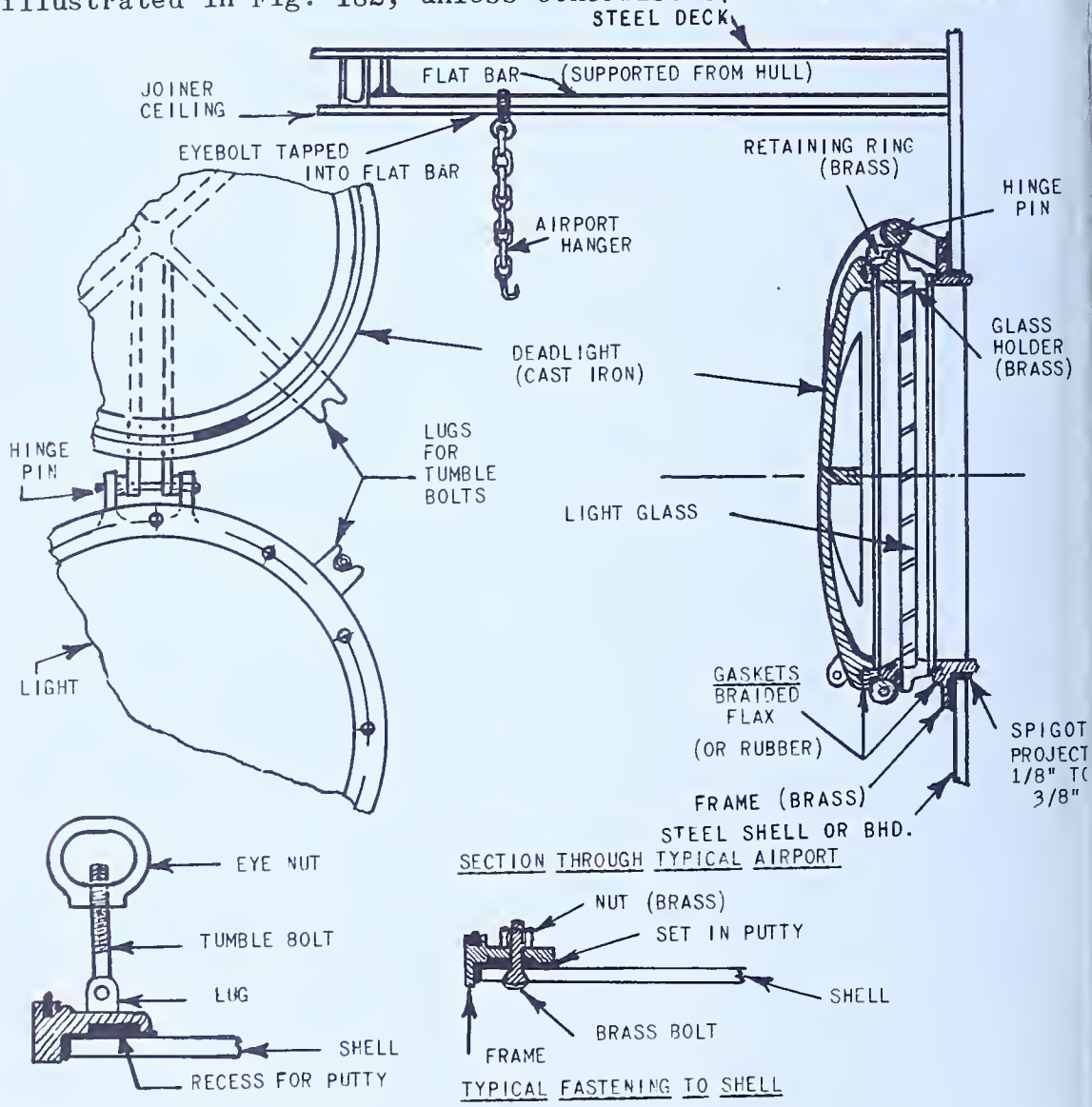


Fig. 182 -- Airport and Hanger

joiner ceiling panels are not sufficiently strong to safely carry the concentrated weight of light and deadlight, a flat bar support is welded over each airport above the ceiling as shown to take the airport hanger. This flat bar is located after the hole is cut and the airport frame is installed. The eyebolt can be tapped into this flat bar. When there is no joiner ceiling, an eyepad can be welded to the steel deck. Fig. 182 shows the construction and

arrangement of the airport. The spigot projects 1/8" through the shell or bulkhead plate and should have 1/16" clearance all around.

Protecting and Installing Airports, Etc.

When the glasses and deadlights are installed, each glass should have a coat of lacquer to protect it from welding or burning sparks. The drawing must be consulted for the location of frosted lights which usually are installed in bathrooms. Fixed lights are similar in construction and installation except that no provision is made for opening them; that is, they are for light and vision only. They may or may not have deadlights for protection. It should be noted that *bolts must be tightened uniformly* when an airport frame is installed. The frame should be put in place (with putty) and fastened lightly with two bolts. All other bolts should then be put in place. The tightening should be done a little at a time, taking up slightly on each bolt and working all around the frame. If one bolt were tightened too much at first, the putty would be squeezed out locally, resulting in a tendency to leak at that spot after the other bolts were tightened. Severe stresses might also be set up in the airport frame, causing distortion which might later cause the glass light to be broken. The same procedure should be followed in tightening any member which is fastened with several bolts, whether or not a gasket is used. For example, care must be taken to uniformly tighten the bolts in hatch covers, manhole covers, portable plates, etc.

Questions

1. How should airport frame bolts be tightened?
2. How are airport hangers supported?
3. How should airport glass be protected from welders' sparks?

ANCHOR HANDLING GEAR

The anchor windlass is a machine for hoisting the anchor chains and anchors when getting under way. It may be driven by steam or electricity. The wheel, or pulley, over which the chain passes is called the wildcat. The wildcat has ribs designed to fit the spaces between the chain links, and thus prevent the chain from slipping. The anchor windlass and related gear are shown in Fig. 183.

The flat bar around the wooden foundation for the windlass is fitted and set by a shipfitter. The padeye in the chain locker (for the "bitter end" of the chain) is located and welded. The hawse pipe is fitted and set. (See page 205 for detailed instructions on fitting a hawse pipe.) The chain stopper and its foundation are located and set. (This foundation should not be welded

solidly until the chain has been installed, making certain that the pawl will drop behind a vertical link when the anchor is pulled hard up). First setting of the chain stopper is done with

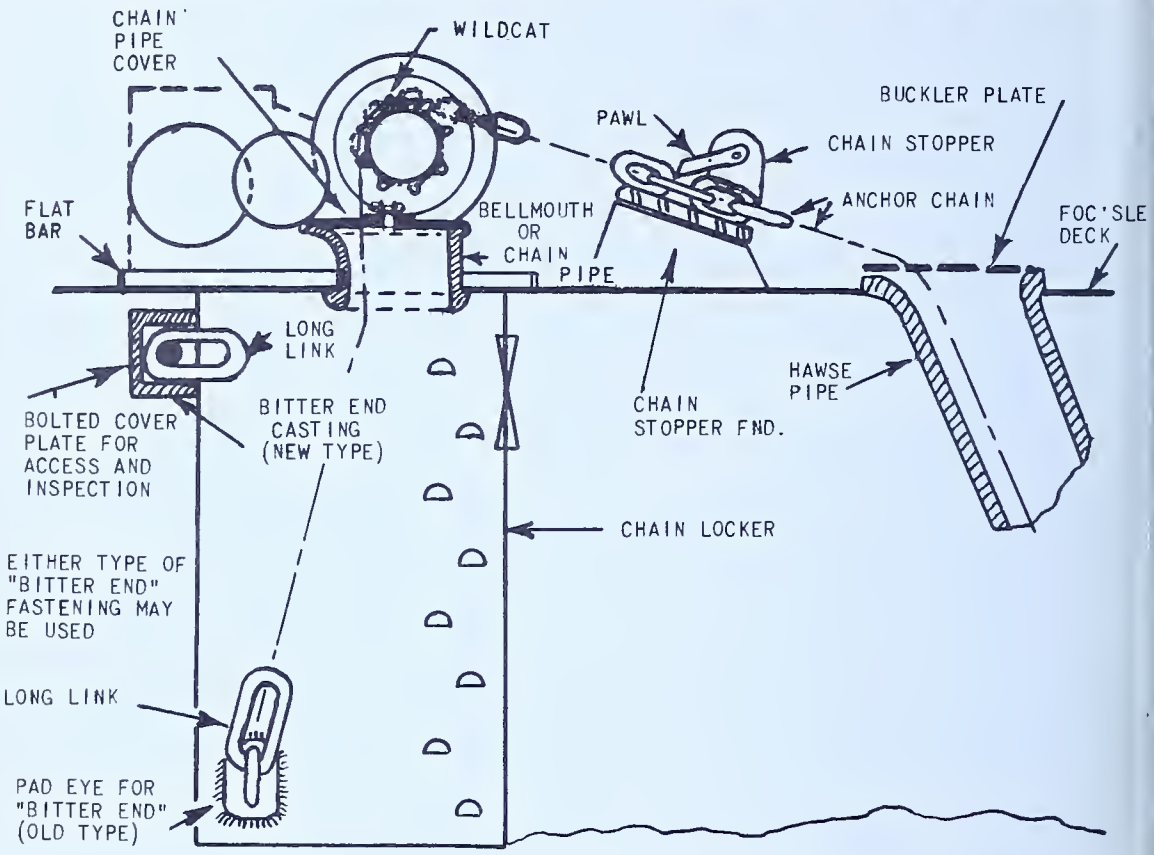


Fig. 183 -- Anchor Windlass and Gear

the aid of a chalk line or string run over the wildcat and down the hawse pipe to represent the contact edges of the vertical links.

Figure 184 shows the *anchor lashing*. This consists of three padeyes as shown, to which are shackled two small chains, each of which passes through a link in an anchor chain. This is a safety precaution to prevent dropping the anchor accidentally if the chain stopper pawl should break or slip.

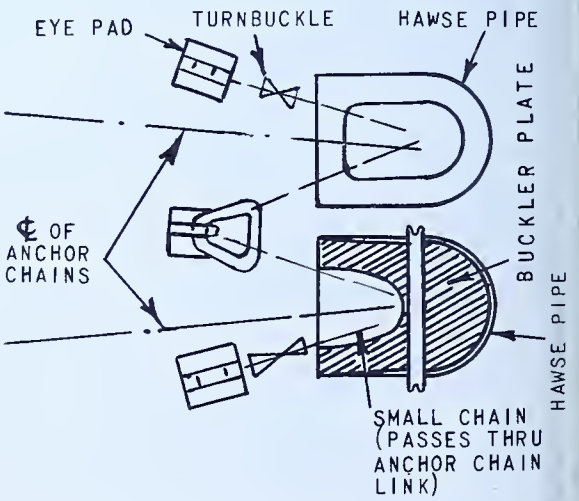


Fig. 184 -- Anchor Lashing

A turnbuckle is shackled into each anchor lashing chain to insure tightness. The older type of gear made use of a hook, or "devils claw," which merely hooked into the anchor chain. The modern rig is safer. When the anchors, chains, and lashings are all pulled up tight in their stowed position, cover plates are fitted over the tops of the hawse pipes and chain pipes, to stop water (and persons) from falling through. The cover over each hawse pipe is called a buckler plate, and is held down by tumble bolts. The cover over the bellmouth or chain pipe is termed a chain pipe cover. Both types must be cut away where the chains pass through them (in the "hard up" position).

Questions

1. What is the shipfitter's work in connection with the installation of anchor handling gear?
2. Explain how a chain stopper is set.
3. How is a buckler plate fitted?

SHIP'S BELLS

The ship's bell (used for calling the watches) is of brass, usually being located on the forward side of the pilot house underneath the visor. A bell cord passes through the front of the house so that the bell can be rung from the inside (see Fig. 185). A small brass tube usually is fitted through the steel and joiner panels as illustrated. The hanger itself is fastened to the steel by means of brass machine screws. The fog bell generally is mounted at the forecastle deck on a kingpost or other convenient support. A short lanyard is fastened to the clapper for ringing the

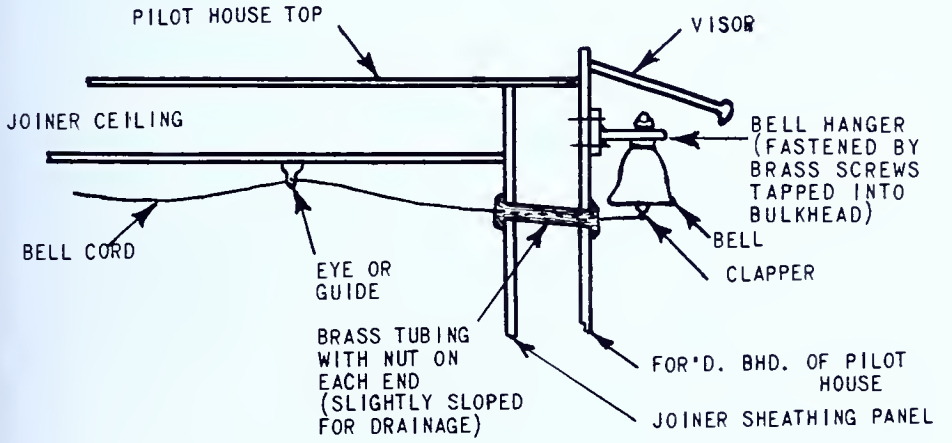


Fig. 185 — Ship's Bell

bell. Some operators require a manually operated trip gong at the after end of the ship in addition to the fog bell forward.

The general alarm is a system of electrically-operated bells which are placed at intervals close enough to be heard by anyone on the ship. They are rung according to prearranged signals in case of fire, collision, or other emergency.

MOORING EQUIPMENT

Bitts, chocks, mooring pipes, and fairleads, are fittings used in handling and fastening the mooring lines of a vessel. They are illustrated in Fig. 186. Bitts and chocks are located according to blue prints issued for this purpose.

Lines coming to the ship from a pier or tugboat first are led through a chock. In some cases plain open or closed chocks are used. Roller chocks reduce the wear on lines. Closed chocks are needed where the pull would tend to lift the lines out of open chocks. For example, the Panama Canal towing system requires closed chocks, since the towing engines are above the deck level of the ship. Mooring pipes are used to pass lines through *high bulwark plates* if closed roller chocks are not fitted. Mooring pipes are castings formed to take the lines with a minimum of chafing. They should not be confused with freeing ports, which are large holes cut in the bulwark plate to allow heavy sea water to drain quickly over the side. Freeing ports are fitted with cross bars to prevent objects from being washed overboard. (See Fig. 197, page 183.)

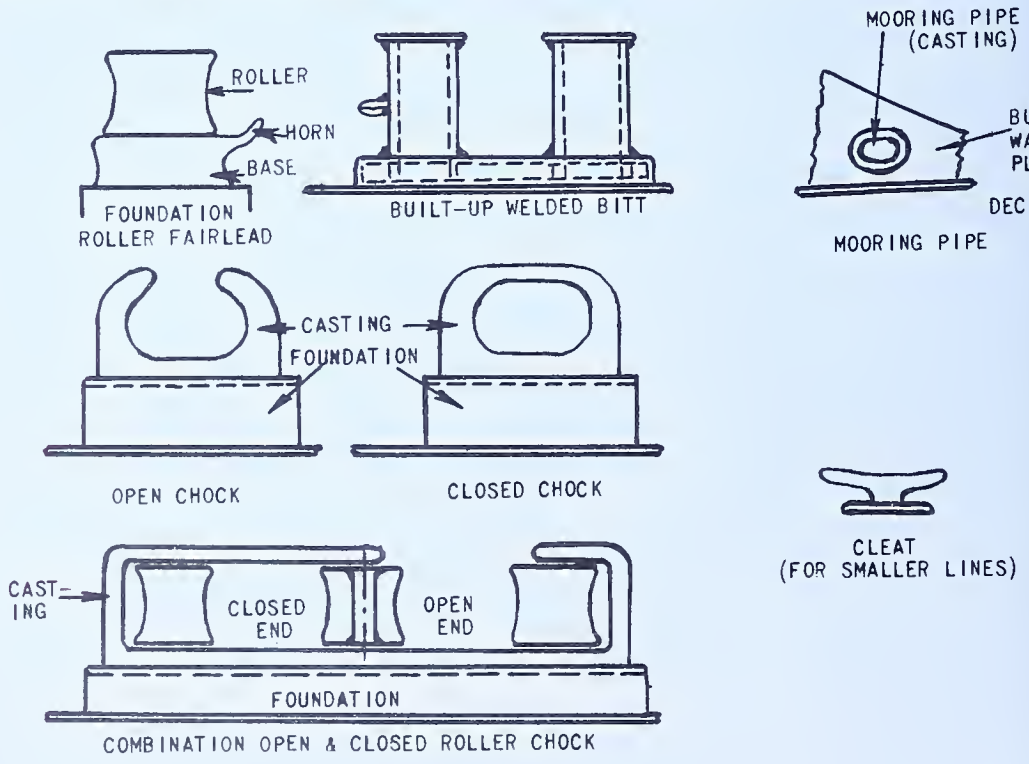


Fig. 186 -- Bitts, Chocks and Fairleads

SETTING FAIRLEAD FOUNDATIONS

Fairleads must be set in line with winch drums, or "niggerheads," to keep the lines clear of possible obstructions and to insure a straight lead to the drum. If line is being hauled in with a winch, it usually passes over a fairlead between the winch drum and bitt, as illustrated in Fig. 187. The method of setting this fairlead is shown in the sketch. It is assumed that a 3" diameter rope will be used, and that it will ride at the end of the flat section of the drum toward the winch as shown. The rope must lead perpendicular

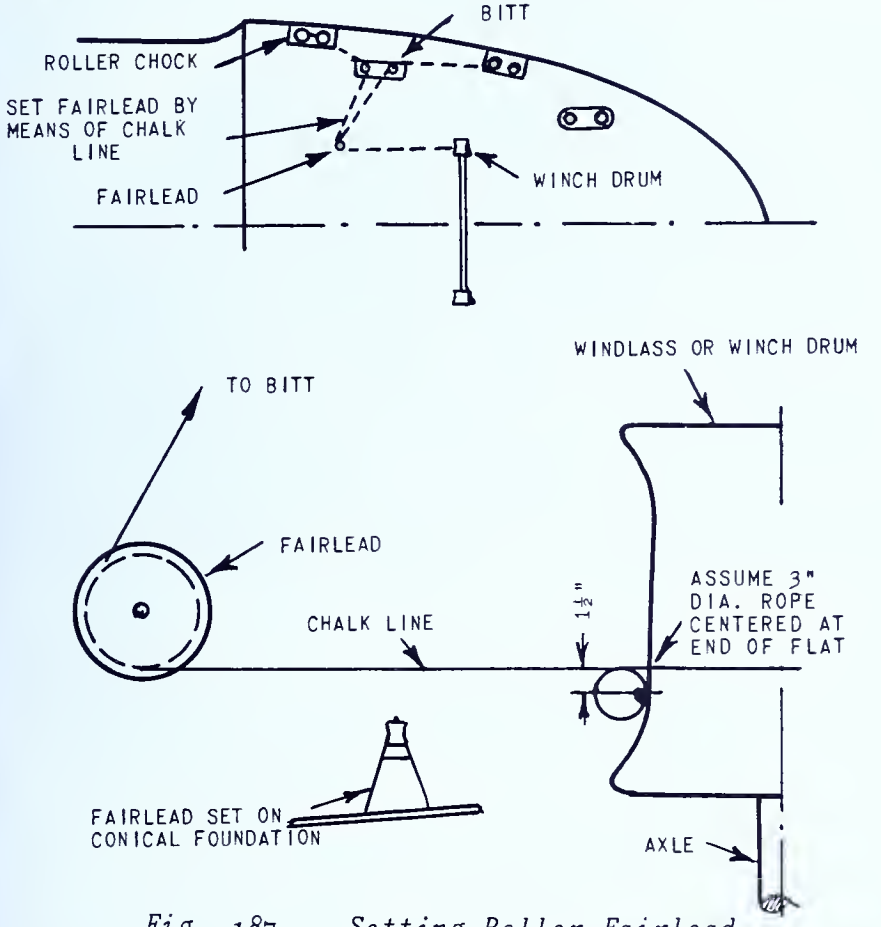
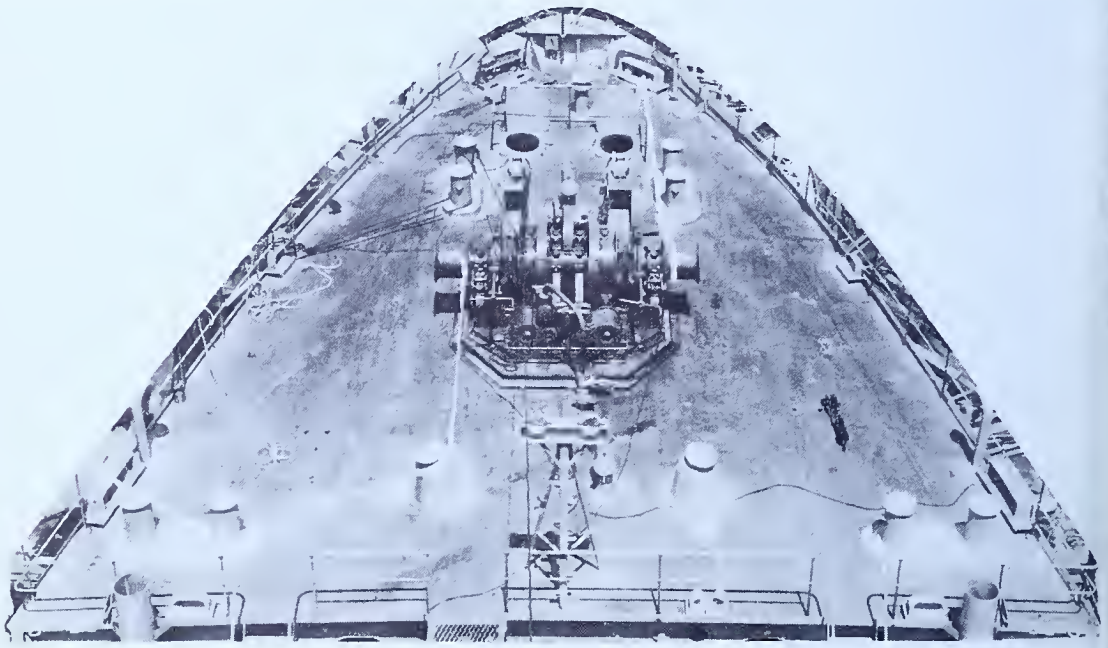


Fig. 187 -- Setting Roller Fairlead

to the axle, so a chalk line is stretched 1½" outboard from this center to represent the outside of the rope which contacts the fairlead. This chalkline is lead around the fairlead and outboard to the mooring bitt as illustrated. The axis of the fairlead must be perpendicular to the plane of the two sections of the chalk line. The bottom of the conical fairlead foundation generally is trimmed to suit, although occasionally the cone is kept plumb and the top is trimmed to allow the fairlead to tilt. The latter method makes necessary the cutting of both the foundation and the base of the fairlead casting.

WINCHES AND CAPSTANS

Winches are of several types. Cargo winches usually are set in pairs at the ends of cargo hatches for handling the booms and runners. (The runners are the lines which actually raise and lower the cargo.) Warping winches are placed as needed for handling mooring lines. The shipfitter is required to set foundations and fairleads, as previously explained.



Focs'le Deck

A capstan is a rotary drum whose axis is vertical rather than horizontal. It is used in handling lines; it is power-driven on modern ships. A capstan is illustrated in Fig. 188. The foundation for the drum is of wood with a flat bar retainer or "finish plate" around it. The fitter must locate and set this plate before the wood is installed. The driving unit, or capstan engine, usually is on a lower deck.

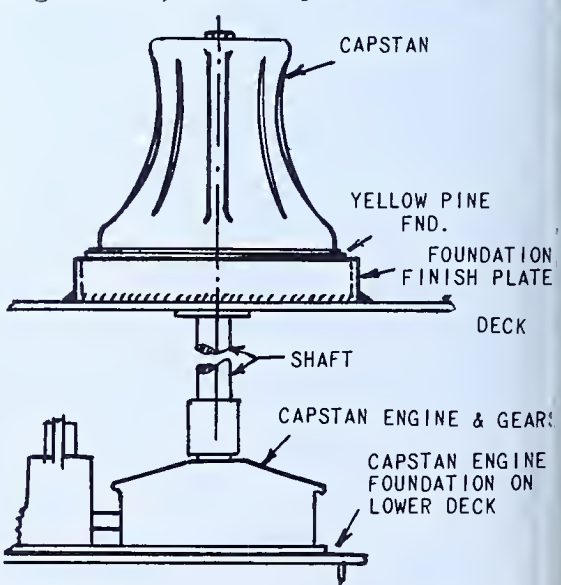


Fig. 188 -- Capstan

Questions

1. What is the function of roller fairleads?
2. What are "mooring pipes"?
3. What is a capstan?

INSTALLING DAVITS

Davits are strong supports which can be extended over the side f a ship to raise or to lower an object clear of the ship's side. ig. 189 shows a stores davit being used to hoist a barrel aboard. his type of davit, with various odifications, is used for hand- ing stores, accommodation lad- ers, bow searchlight, oil hoses, tream anchors, etc. The main ifference in these davits is heir location on the ship. One avit often is used for various obs. One duty of the ship- itter is to properly locate the avit pedestals and set them in uch a manner that the con- acting leg of the davit will be ertical; otherwise, the davit ill tend to swing around, owing o its own weight. After the pedestal (which may be a casting, forging, or built-up construction) is welded in place, the davit is installed (with plenty of grease at all contact surfaces). It should be made certain that the rounded bottom of the davit rests on the spherical bearing or heel-piece.

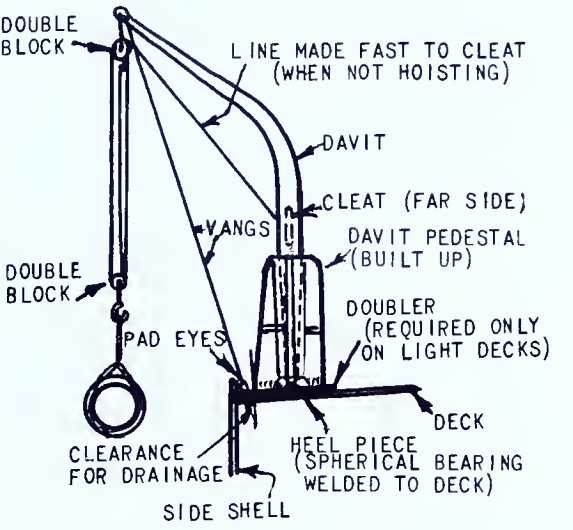


Fig. 189 -- Stores Davit

Two pad eyes usually are welded to the deck (a few feet forward and the same distance aft of the pedestal) for securing the vangs (or guys) which hold the davit in position. Lifeboat davits are used for raising and lowering the lifeboats over the side of a vessel. They are of many designs and shapes, the object being to make them as dependable and fool- proof in operation as possible.

One of the most common types of lifeboat davit is the Welin davit, which is illustrated in Fig. 190. To lower the boat, it is necessary to turn a crank, which rocks the top of the davit outboard. This allows the boat to swing clear, so that it may be

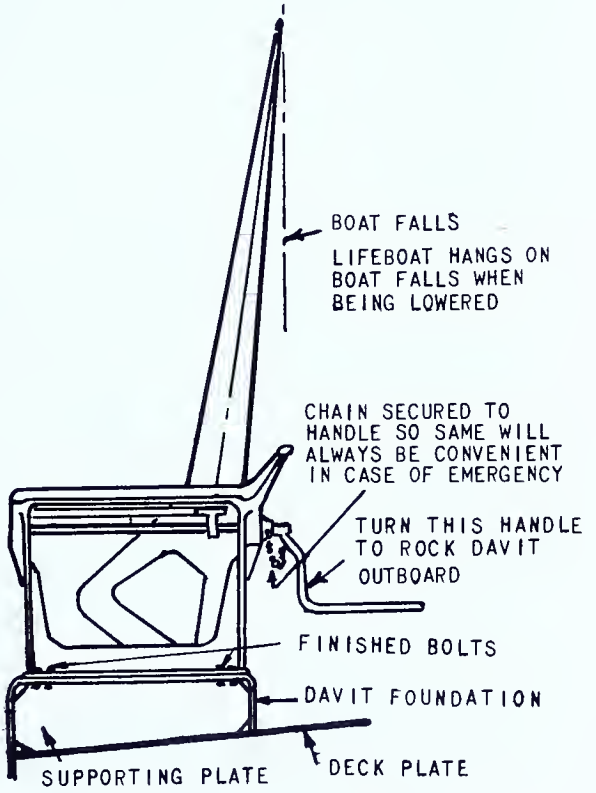
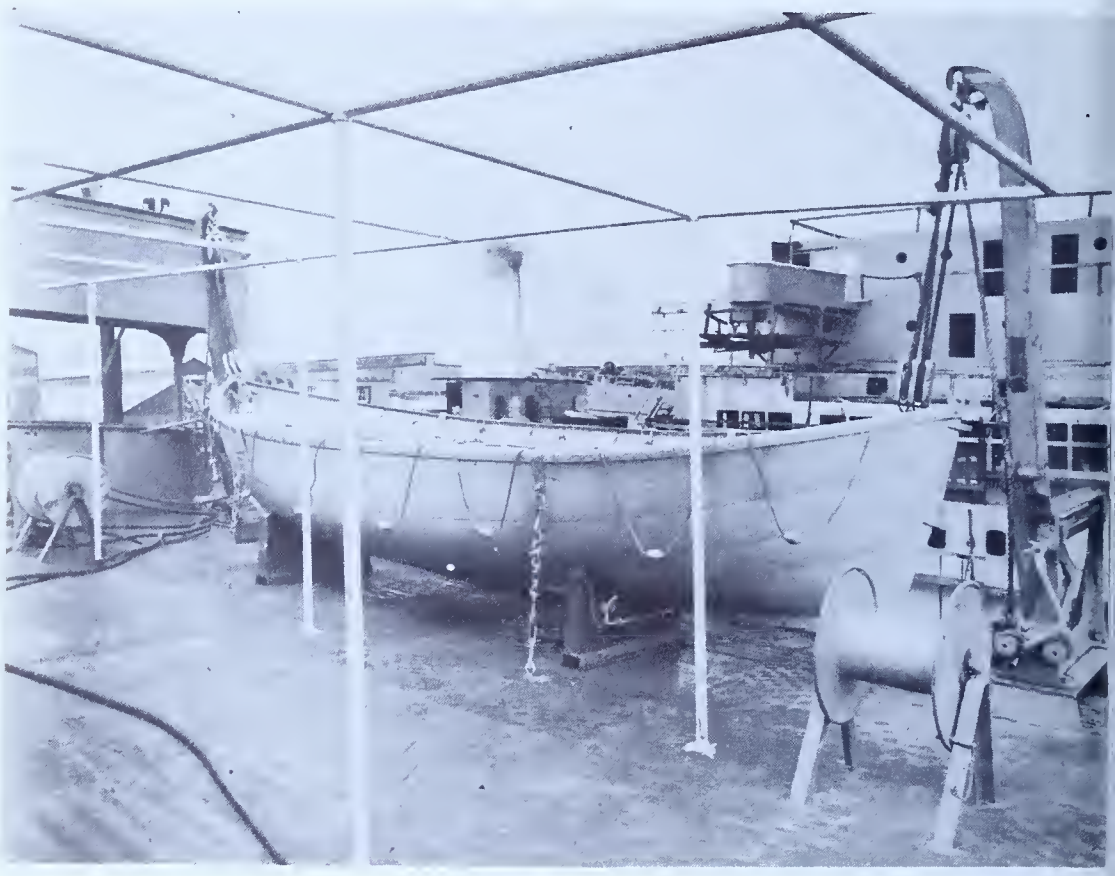

BOAT FALLS
LIFEBOAT HANGS ON BOAT FALLS WHEN BEING LOWERED
CHAIN SECURED TO HANDLE SO SAME WILL ALWAYS BE CONVENIENT IN CASE OF EMERGENCY
TURN THIS HANDLE TO ROCK DAVIT OUTBOARD
FINISHED BOLTS
DAVIT FOUNDATION
SUPPORTING PLATE
DECK PLATE

Fig. 190 -- Lifeboat Davit

dropped to the water's surface by slacking away on the boat falls Foundations for lifeboat davits are set according to blue print and leveled as previously explained.



Lifeboat Stowage and Handling Gear

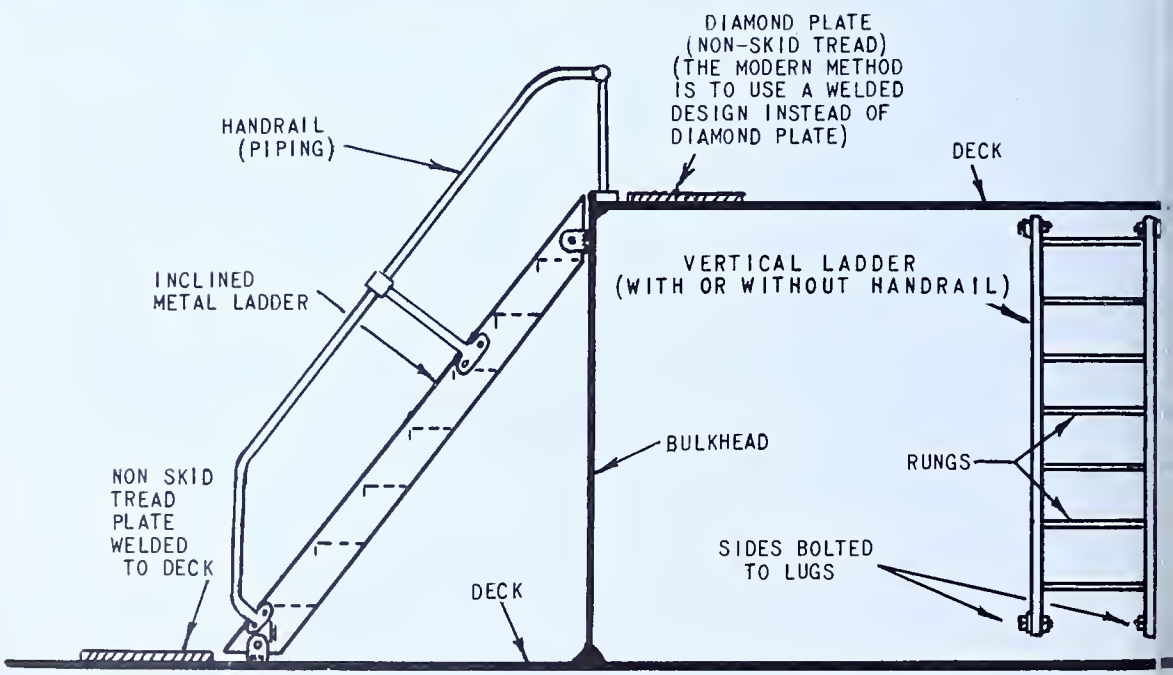


Fig. 191 -- Inclined and Vertical Steel Ladders

INSTALLING DECK LADDERS

Deck ladders are used for access from one deck level to another. teel ladders are installed by shipfitters, and usually are fastend as shown in Fig. 191.

The top and bottom of each side piece are bolted to lugs which re welded to the deck and bulkhead. Skid-proof treads of diamond late often are welded to the decks close to the top and bottom f the ladder, to prevent slipping. (Handrails usually are made nd installed by pipefitters.)

INSTALLING STEEL DOORS

Doors are of various sizes and shapes, depending on their loation and purpose. Wooden doors or light metal joiner doors are ised in quarters and on superstructure decks. Non-watertight steel loors are used in engine casings, around quarters, at provision or locker rooms, crew's shower rooms, and in various other places. Watertight steel doors are used on shelter decks at entrances to superstructure spaces, and in other locations as specified.

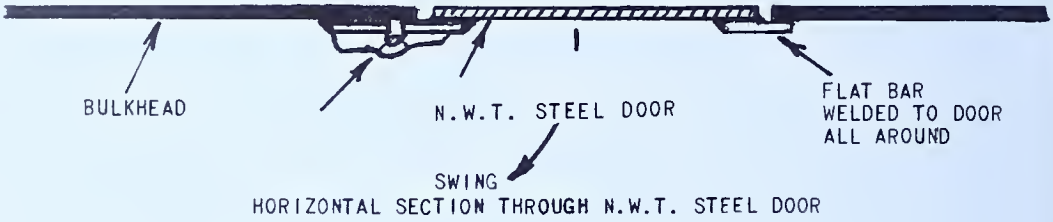
NON-WATERTIGHT STEEL DOORS

A non-watertight door essentially is a hinged steel plate with knob, latch, and lock, as illustrated in Fig. 192. The hole is cut in the bulkhead to the proper size and trimmed by chipping. A wooden template is made to fit the opening with a clearance of 1/8" all around. The template is taken to the shop and the door made to suit. To install the door, it is necessary to dog it in place, (taking care to maintain the correct clearance at sides, top, and bottom) and have the hinges tacked and welded to the bulkhead. The locks and doorknobs are fitted after the doors are installed. *Extreme caution is necessary to avoid mixing the keys.* As soon as a lock is fitted to a door, the corresponding key (or keys) should be wired to a tag on which is marked the exact location of the door, including deck, frame number, port or star-

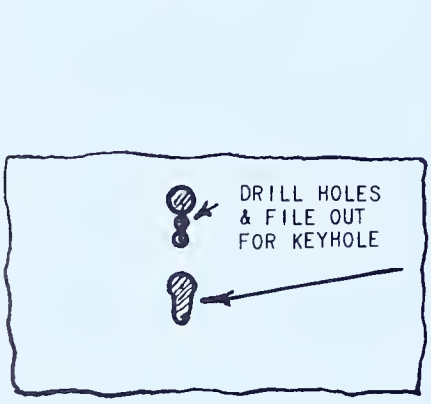
Non-watertight Steel Door Showing Hinges, Lock, and Hook

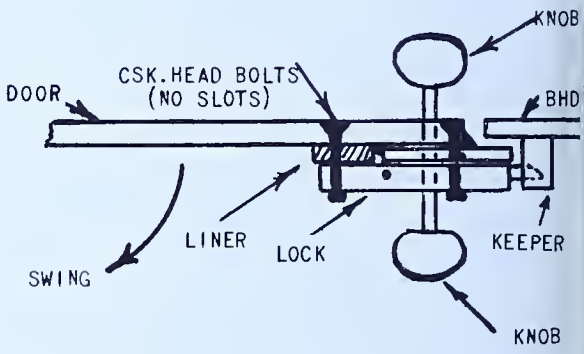
board, hull number and name of the space to which the door gives access.

In Fig. 192 are also shown locks fitted on this type of door with and without "keepers." Need for a keeper depends upon which side of the door is the protected space. This protected, or "locked-up" space, is the side upon which the lock mechanism should be



HORIZONTAL SECTION THROUGH N.W.T. STEEL DOOR





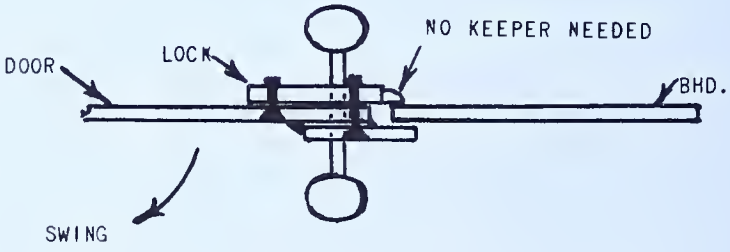


Fig. 192 -- N.W.T. Steel Door (One Type)

placed. In either case, a keyhole must be cut through the steel door. This is done by drilling two or three holes and filing the opening to the right shape. Most locks can be taken apart and the latch and keeper turned over to make either a right or left hand lock. After the lock is installed, it should be well oiled or greased, mainly to prevent paint from fouling the mechanism.

WATERTIGHT DOORS

In Fig. 193 is shown a section through a watertight door and a detail of one of the dogs which hold the door tightly closed.

sually either four or six of these dogs are provided for each oor. A handgrab and a locking device (for padlock) are specified here needed. The American Bureau of Shipping Rules require the eight of door sills to be as follows:

18" on freeboard deck except at the engine and boiler casing where 24" is required.

15" on superstructure deck except at companion hatches to freeboard deck, where 18" is required.

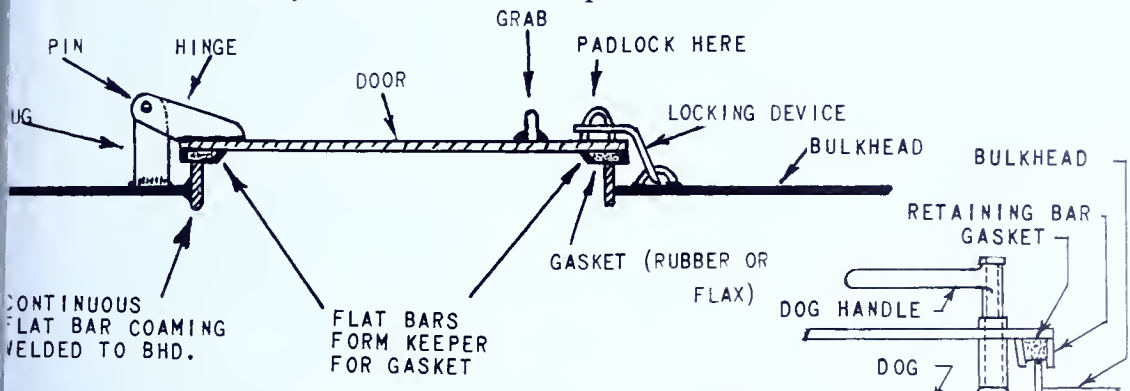


Fig. 193 — Horizontal Section of Watertight Door

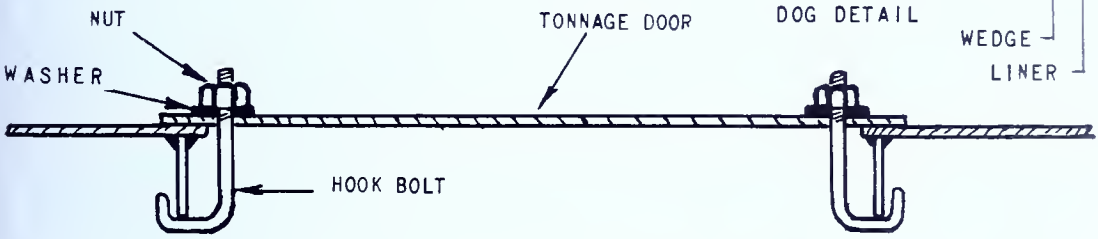


Fig. 194 -- Tonnage Opening and Door

Gas tight doors may have any type of gasket that will make an air seal. They need not resist any appreciable hydraulic or pneumatic pressure. Tonnage openings are holes of specified minimum area cut for the sole purpose of exempting certain compartments from tonnage measurement, and, therefore, reducing the cost of many duties which depend on registered tonnage of the ship. No gaskets are allowed on tonnage doors or covers. They are prohibited from being watertight. The usual method of securing such covers is by means of hook bolts which fasten to a stiffener on the bulkhead. These bolts are spaced *not closer* than 12" center to center.

Watertight Door

EXPANSION JOINTS

Expansion joints, as illustrated in Fig. 195, generally are fitted at intervals in the longitudinal members of the fore-and-aft gangway to prevent undue stresses when the ship sags or hogs

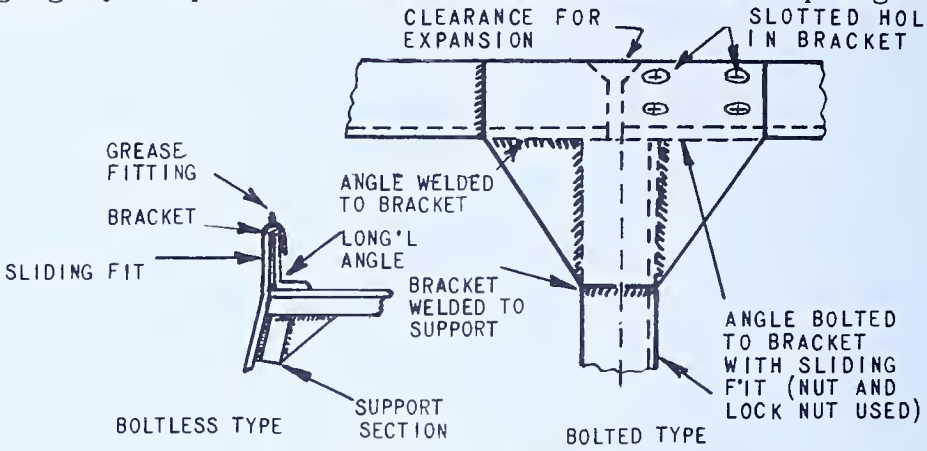


Fig. 195 -- Expansion Joints

owing to loading differences or wave motion. These joints also will allow for any difference in longitudinal expansion caused by temperature changes.

INSTALLING FIRE EQUIPMENT

Fire fighting equipment usually is located and stowed by shipfitters to comform with requirements of the Bureau of Marine Inspection and Navigation and the owner's representatives.

Fire extinguishers (portable) and fire axes must be distributed about the ship in convenient locations. These are fastened to bulkheads with brass fittings which permit instant removal for use.

Water hydrants for use in case of fire also are provided. The site of each of these is called a fire station, and here always is stowed at least one fire hose (on a reel or a hose rack). A spanner wrench and a nozzle for each hose are supplied and properly secured.

Carbon dioxide gas is stored under pressure in (steel) bottles, from which pipes are led to cargo holds, tanks, and other protected spaces. The shipfitter must make a foundation or stowage for the CO_2 bottles. Blue prints are issued for the securing of these flasks.

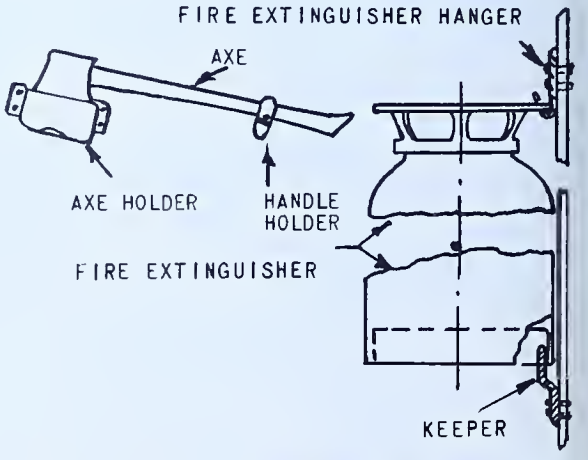


Fig. 196 -- Hangers For Axes and Extinguishers

FREEING PORTS AND SCUPPERS

Freeing ports, as previously mentioned, are large holes cut in he bulwark plates to free the deck of water which may result from wave breaking over the eck. A steel doubler plate ust be welded on the bul- ark to compensate for the teel cut away. The trans- erse section area of the oubler *must equal or exceed* he transverse section area f the piece cut out. A typi- al freeing port is shown in ig. 197.

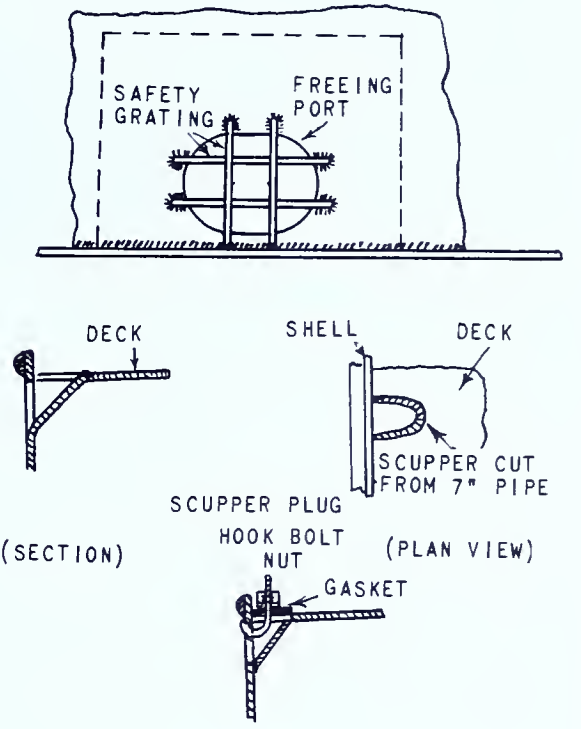


Fig. 197 -- Freeing Port and Scupper Also Scupper Plug

Limber holes, or drain oles are cut in floor plates nd longitudinal girders, o prevent water or oil from tanding in pockets and to id flow toward bilge wells r suctions. Scuppers may rain over the side directly, s that shown in Fig. 197, r they may empty at a lower evel, carrying the water through pipes (in which case they are installed by pipe- fitters). Figure 197 also shows one type of scupper plug. Such plugs are used when the ship's side is be- ing painted, or when, for any other reason, the water must be prevented from flowing off the decks. (Gasket usually is rubber.)

FITTING HATCHES AND MANHOLES

Hatches are, essentially, holes cut in the deck for access to holds and for the loading and unloading of dry cargo. Provision must be made for tightly closing these hatches, especially on the shelter deck or main deck.

Oiltight hatches as used in tankers often have strongbacks so designed as to force down the covers in the center, causing equal pressure on the sealing gaskets all the way around (see Fig. 198).

Cargo hatches for dry cargo may be any of several types. Such a hatch usually consists of a large rectangular opening fitted all around with deep strong girders which are built to serve as

coamings. Across the hatch opening are portable beams (usually beams) which are supported by rests welded to the girder at eac side of the hatch. Also welded to this girder are hatch bea guides which keep the beam erect and prevent fore and aft motion These rests and guides must be located and set by the shipfitter These members are illustrated in Fig. 199.

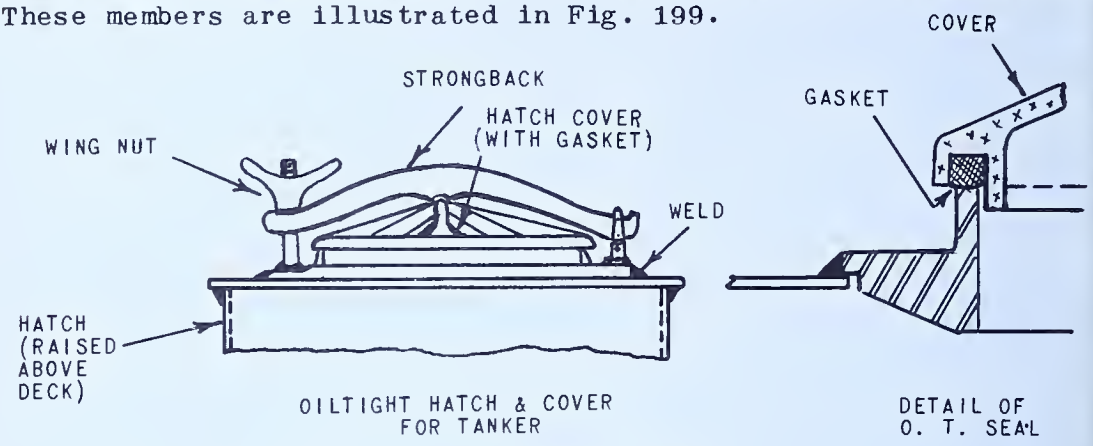


Fig. 198 -- Oiltight Hatch

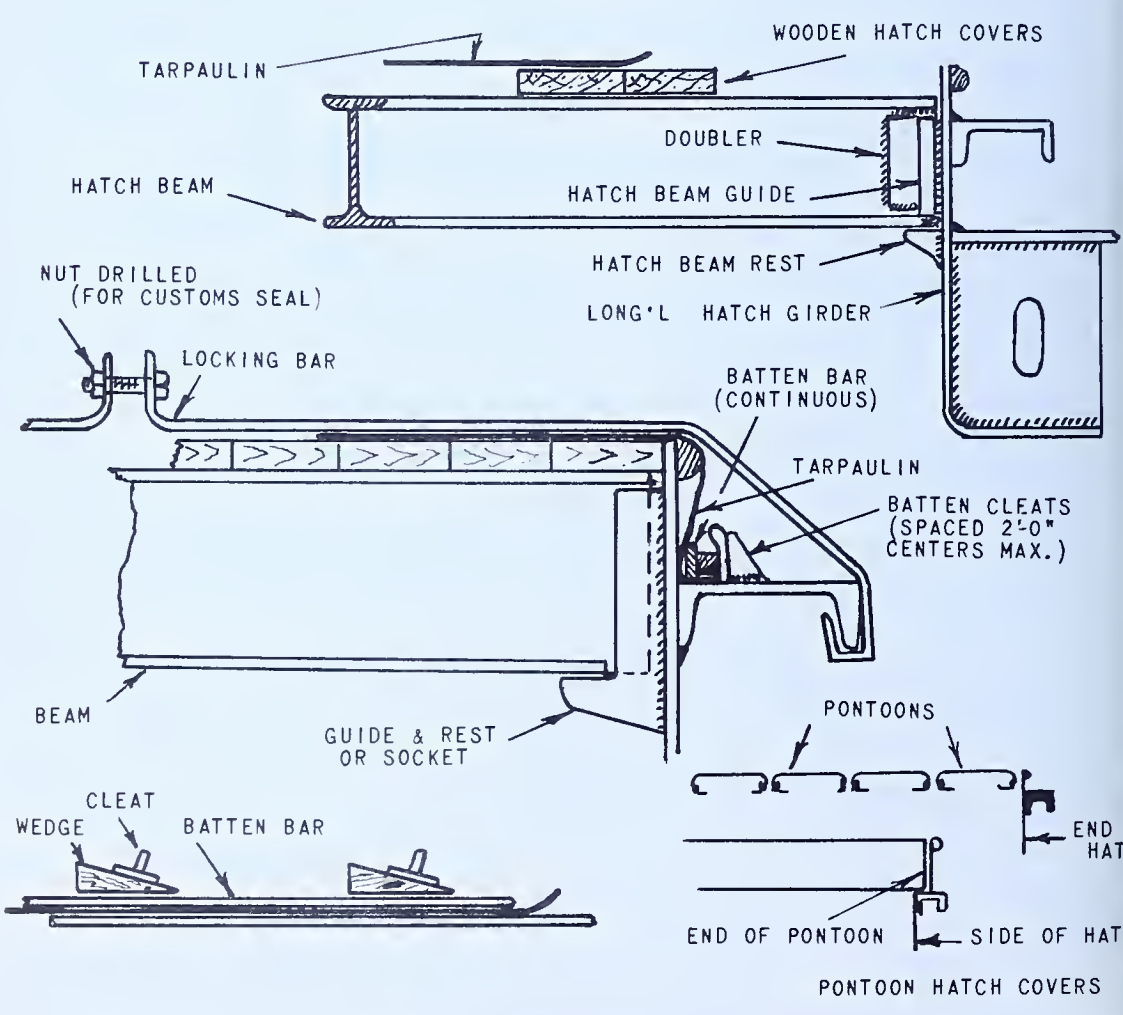


Fig. 199 -- Cargo Hatch and Covers

A tarpaulin stretched over the wooden covers makes the hatch watertight. The continuous batten bar is tightened all around against the tarpaulin by wedges bearing against the batten cleats. These cleats must be spaced not more than 2'-0" between centers. A cleat must be placed within 6" of each hatch corner on each side. Locking bars are fitted as shown to secure the hatch covers. The nut and bolt which fasten each locking bar are drilled to receive a custom house seal.

Figure 199 also illustrates a hatch with a "pontoon" hatch cover. The pontoons consists of box-shaped steel members as shown, sufficiently long to reach across the hatch and rest on ledges on the longitudinal hatch girders. Their width is such that six or eight of them will close a hatch. No wooden covers are required. Pontoon hatch covers *will not float;* the name is derived from the similarity in appearance to real pontoons. The reason for use of this type cover is that they are sturdier than the usual combination of hatch beams and wooden covers. When not fitted throughout the length of the ship, pontoon covers generally are used on one or two of the hatches at the forward end where the heavy seas break aboard most frequently.

MANHOLES AND COVERS

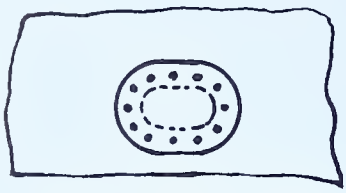
Manholes are placed in decks, innerbottoms, bulkheads, etc., to provide access to the spaces below or beyond. Many of these manholes must be fitted with covers which will stop oil, water, or other liquid from passing. Manhole covers may be bolted plates or dog-type covers. Both are illustrated in Fig. 200. The bolted plate manhole cover is installed as shown. A hole is laid out on the deck at the correct location and burned out a half inch outside of the inner edge of the ring as shown. (Ring, studs, and cover plate usually come from the shop assembled). The ring is set in place evenly over the hole, wedged tightly and tack welded. To avoid distortion, the cover should be put on and tightly bolted while all the finished weld that is possible is being made. (This should be done with any welded door or hatch cover or other type manhole cover).

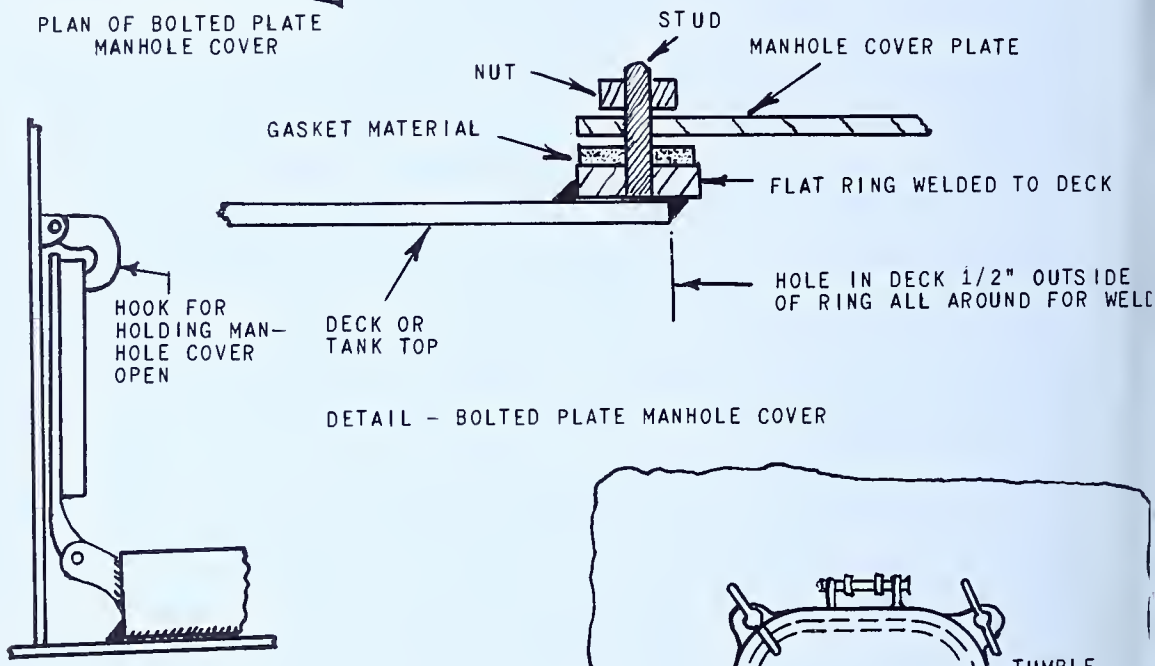
Gasket material for a watertight bolted plate manhole cover may be trunk board, flax, or rubber. Gasket material for an oiltight bolted plate manhole cover may be trunk board, or oil proof gasket material such as oilene, flax, or special rubber composition.

DOG-TYPE MANHOLES

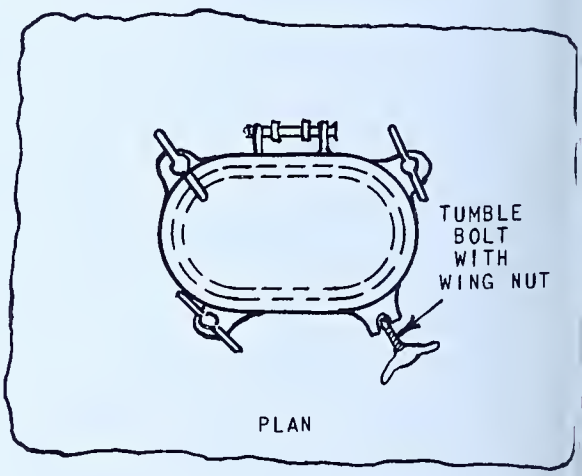
The dog-type manhole with raised coaming is set in much the same manner. The hole in the deck should be cut 1/2" inside of the inner edge of the coaming plate for welding. If a manhole is watertight, the gasket may be rubber or braided flax. If a manhole is oiltight, braided flax, or a special oil-resisting rubber composition can be used for a gasket.

Other types of manhole covers sometimes are used for special purposes, but those mentioned are the most common. Fig. 200 also





DETAIL - BOLTED PLATE MANHOLE COVER



Raised Water-tight Manhole

DOG TYPE - MANHOLE COVER

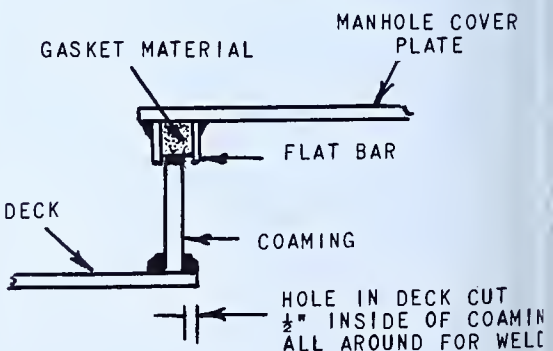


Fig. 200 -- Manhole Covers

shows a "hook" cut from a plate and bolted to a pair of lugs for holding a hinged manhole cover open when it is close to a bulkhead.

SETTING OR FITTING NAVIGATING EQUIPMENT

Navigating equipment is in some cases set, located, or fitted by shipfitters. Sometimes a steel foundation is made for a sounding machine, a pelorus, or a binnacle. (A binnacle is the mounting or casing in which a magnetic compass is set.) Such foundations should be as simple as possible and yet serve their purpose. Often a channel or a pair of angle clips welded to the steel deck will form a satisfactory mounting. The standard compass (on top of the pilot house) often is set on a heavy copper base to keep it as far from any steel work as possible. Fig. 201

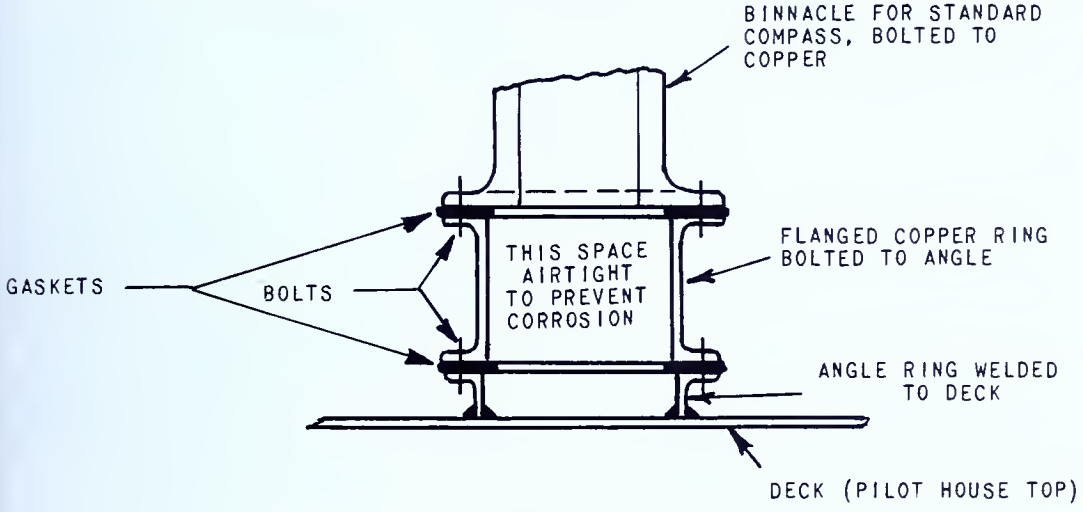

BINNACLE FOR STANDARD COMPASS, BOLTED TO COPPER
FLANGED COPPER RING BOLTED TO ANGLE
GASKETS
BOLTS
THIS SPACE AIRTIGHT TO PREVENT CORROSION
ANGLE RING WELDED TO DECK
DECK (PILOT HOUSE TOP)

Fig. 201 -- Binnacle Foundation

illustrates such a base. In some installations, no steel is permitted within a 15 foot diameter circle with the compass at the center. Railings, fittings, etc., are all of brass or wood within this so-called "non-magnetic circle."

SCREENING NAVIGATION LIGHTS

Range lights, usually located on the masts, are set on brackets which are installed by shipfitters. These lights, particularly the forward one, should be screened or shielded on the under side to prevent any possible reflection from the deck which might interfere with the vision of the helmsman or officer on the bridge. The running lights (red to port and green to starboard) are set in recesses or "lighthouses" at the sides of the navigating bridge. They are required to have a screen at each light projecting three feet forward so that the light will not show across the bow; that is, a person at the extreme forward end of the forecastle deck must not see either the red or the green light. (See Fig. 202.)

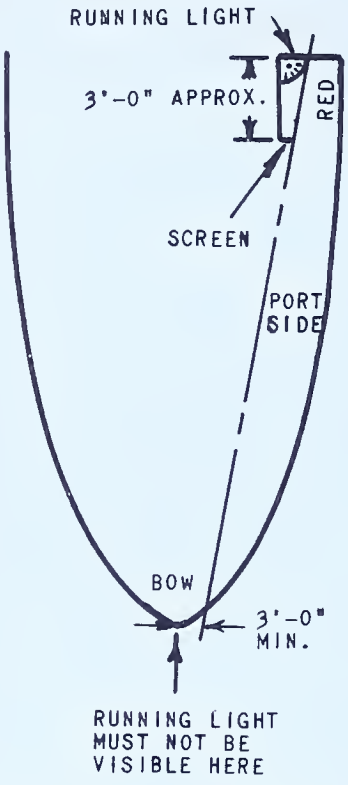


Fig. 202 -- Running Light Screen

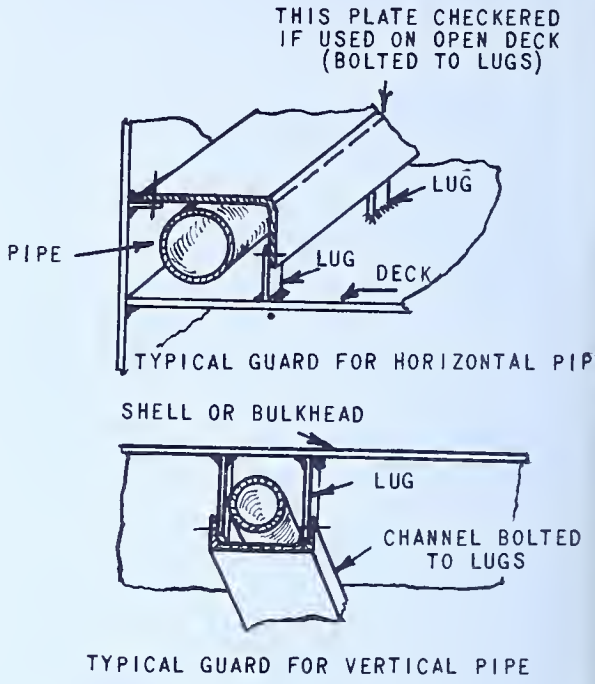


Fig. 203 -- Pipe Protection

FITTING PIPE PROTECTION

Pipes, operating rods, cables and lights usually are protected by shipfitters from damage by cargo or by other objects. All such protection is made portable so that the pipes or other members will be accessible and removable.

Protection in the holds is composed of ordinary plates and shapes, cut and flanged to suit. Protection of horizontal pipes or other members on an open deck generally includes a top cover of checkered or diamond plate to prevent slipping.

There are an infinite number of variations in the design of pipe protection. Fig. 203 shows the principle involved. All pipe protection must be removable.

FITTING RIGGING AND ATTACHMENTS

Rigging consists of masts, booms, kingposts, yards, etc., and also the fittings, wire and manila ropes involved in the securing or handling of these members.

Masts on cargo ships are designated as fore, main and mizzen masts (beginning at forward end). A mizzen mast usually is not fitted. The lower or larger section of a mast structure is called the mast, and the lighter top section is called the topmast. Setting a mast in the ship to the proper rake has been explained on page 114. The same procedure is followed in setting a kingpost.

Arrangement of masts, kingposts and booms may be seen in Fig. 179 and Fig. 181, as well as names of the more important ropes or lines. Pads are welded on each mast for fastening the stays and shrouds. The shipfitter must locate and set the deck pads for the corresponding wires so that the stays will lead fair, as illustrated in Fig. 204. Owing to the rake of the mast, a pad for a

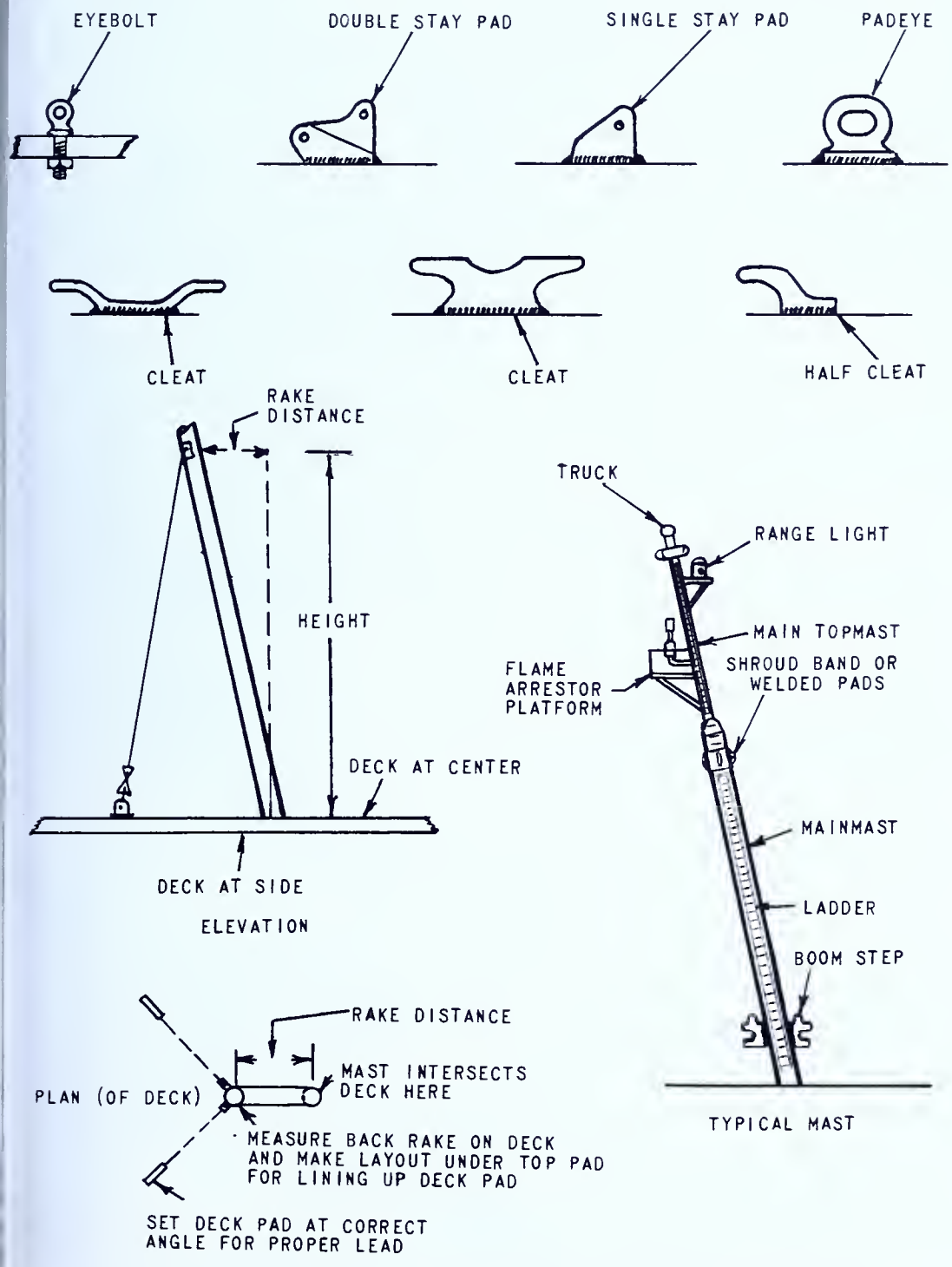


Fig. 204 -- Layout of Rake Distance on Deck for Setting and Aligning Deck Pads for Shrouds and Stays

sidestay or shroud would not lead fair if aligned with the base of the mast. Separate layouts must be made for different heights above the deck. Smoke stack stay pads are similarly set.

Figure 204 also illustrates several types of pads and cleats for securing lines to decks or bulkheads. The locations of cleats usually are specified on drawings, but must sometimes be changed to suit the operating personnel.

LOG AND SOUNDING EQUIPMENT

Sounding equipment of various kinds is used to determine the depth of the water in which the ship is floating. The simplest sounding device is a lead weight (called a blue pidgeon) on the end of a light line marked off in fathoms. (A fathom is six feet.)

To enable the leadsman to work clear of the ship, a small platform with a safety rail often is installed amidships on each side of the vessel at approximately the height of the lifeboats. These platforms can be removed or folded against the ship when not in use.

Several types of mechanical sounding machines are in common use. A thin wire is wound on a reel and arrangements are made for dropping to the bottom of the sea a weight fastened to this wire. A specially treated glass tube lowered with the weight registers depth as indicated by maximum water pressure. A "sounding boom" is rigged out from the shell alongside the machine with a sheave over which the wire runs clear of the hull. The sounding boom and fittings are located and set by a shipfitter. (See Fig. 205.)

FATHOMETER

A fathometer is a device by means of which a sound wave is sent out from the bottom of the ship. A measurement is made of the time it takes for this wave to go to the ocean bottom and echo back to the ship.

Since the speed of sound in water is known, the depth of water can be calculated. The shipfitter makes a watertight compartment for the fathometer equipment and installs some type of shell flange for the oscillator and the receiver.

THE SPEED LOG

In Fig. 205 (at the right) is illustrated a log boom with the log, log wire, and rotor, which are used to determine the speed of the

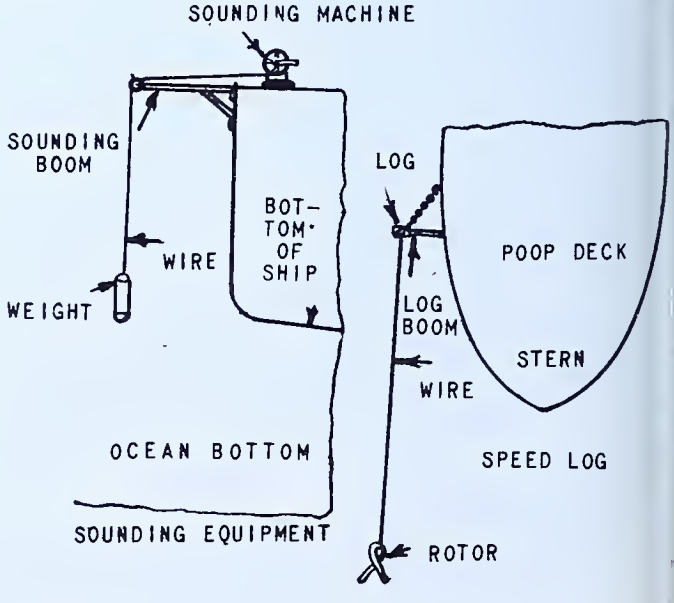


Fig. 205 -- Sounding Machine and Log

ship. The rotor, on the end of a wire, spins like a propeller as the ship travels through the water. This rotation is transferred by means of the wire to a log, or counting mechanism, at the end of the log boom. The number of rotations on the rotor in a given time are used in estimating the vessel's speed. The log boom keeps the rotor to one side, out of the propeller wash. This speed log should not be confused with the ship's log or the engineers' log; these are important records kept for reference. A log desk is a desk in which a log book is kept and used.

VENTILATING EQUIPMENT

Ventilation must be provided for engine rooms, quarters, and cargo spaces. Natural ventilation is provided by means of ducts which take the air in through cowls, mushroom heads, or other ventilator heads, and allow it to circulate through the various spaces after which the air is exhausted to the atmosphere. Mechanical ventilation accomplishes the same result with the aid of blowers. Most ventilator ducts and cowls, and other type vent heads, are made and installed by sheet metal workers. Shipfitters are required to make and install any heavy trunks, mushroom ventilators, air ejectors, or ducts which are part of the hull structure.

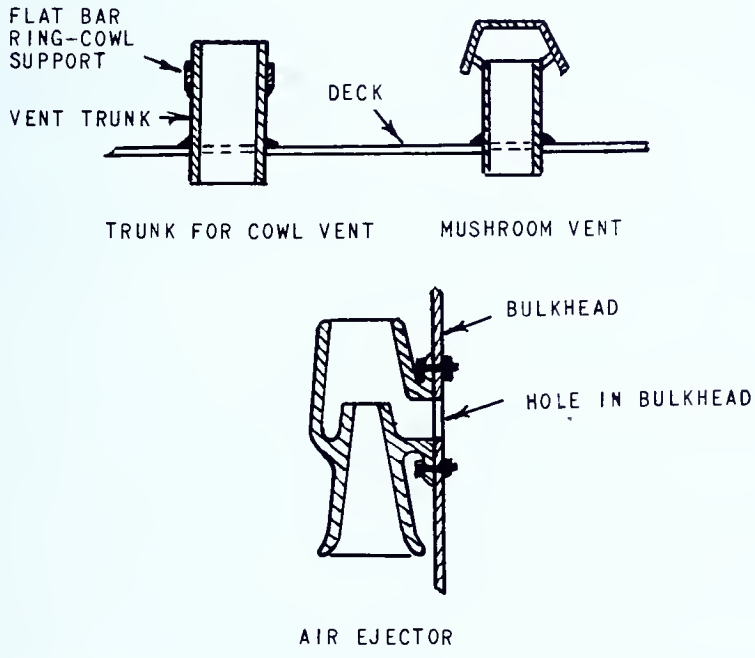


Fig. 206 -- Ventilators Usually Installed by Shipfitters

MISCELLANEOUS STOWAGES AND FASTENINGS

Stowages for many kinds of gear must be built on the ship. Heavy spares, such as propellers and anchors, require sturdy foundations and secure fastening. Such stowages usually are specified and drawings are issued for their construction. Sheet lead protection is provided between brass propeller blades and any supporting arm or bracket.

Suitable supports or cradles are made for securing the accommodation ladder and shore gangway, usually in the bridge space or alongside the fore-and-aft gangway. Brackets usually are fitted within the bridge space for stowing sections of oil hose and Butterworth gear. Many other stowages must be installed by shipfitters. At stowages or foundations which are so constructed as to form pockets in which water might lie, drain holes or limber holes should be cut, where necessary, to prevent the accumulation of water. Small or inaccessible compartments, such as binnacle foundations or long pipes, should be made airtight, by means of welding or gaskets, to prevent corrosion.

Life rings are canvas-covered cork rings, sufficiently buoyant to support any person who might fall overboard. Many of these rings are distributed about the decks of the ship, where they can be quickly thrown into the water. Some ring buoys are equipped with lights which automatically show when the ring hits the water. Life rings are hung in metal supports or hangers which are lashed to the ship's rail or attached to steel bulkheads or deck houses. In the latter case, the hangers are welded or bolted in place under the direction of a shipfitter. Life rings must be located with the approval of the Bureau of Marine Inspection and Navigation. (Steamboat Inspectors.)

FITTING CAUTION SIGNS

Caution signs are posted in various parts of a ship to warn against smoking, naked lights, etc. When installed they should be kept clear of the steel bulkhead to allow the surface behind them to be painted. This is generally accomplished by means of small brass pipe ferrules as illustrated in Fig. 207.

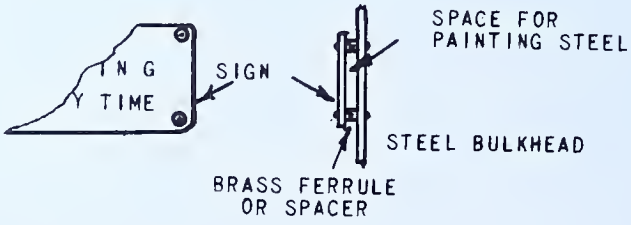


Fig. 207 -- Caution Sign Installation

PART IX

Construction of an Oil Tanker

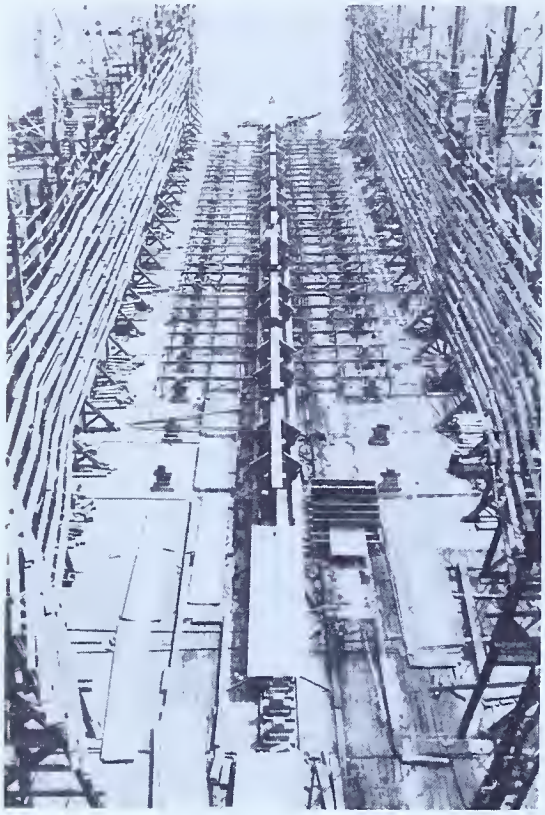
PROGRESSIVE STAGES

The photographs on the following pages show progressive steps in the construction of an oil tanker from the laying of the keel until delivery to the owners. This vessel is 543'-0" in over-all length, 70'-0" moulded beam, with a deadweight of 19,402 tons.

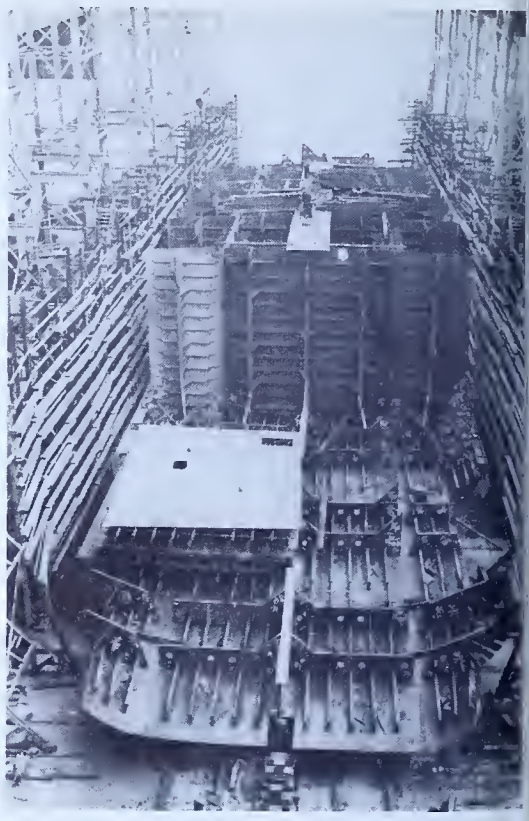
1. *First Day*--This photograph shows the flat and vertical keels in place, together with rider plate and connecting brackets for web frames.
2. *Second Week*--The majority of the bottom shell sections are in place. Also, longitudinal bulkheads and a strake of upper deck in four tank sections have been erected.
3. *Eighth Week*--All of the cargo tank sections have been erected, including bulkheads, side shell, and practically all of the deck plating.
4. *Eleventh Week*--About ninety percent of the hull has been erected. This view shows the bow assembly and mid-ship deck house in place.
5. *Fourteenth Week*--The hull is now completely erected; all craftsmen are finishing their work. Anchor windlass, fore and aft gangway, oil-tight cargo hatches, bitts, chocks, and other hull fittings are visible.
6. *Sixteenth Week*--This view, taken from the launching platform, shows the ship sliding down the launching ways.

   Prior to launching, the ground ways and sliding ways must be placed in position under the ship. After the launching ways are in position, the shoring, and bilge and keel blocking are removed, so that the ship rests entirely on the launching ways, ready for release at the proper moment.

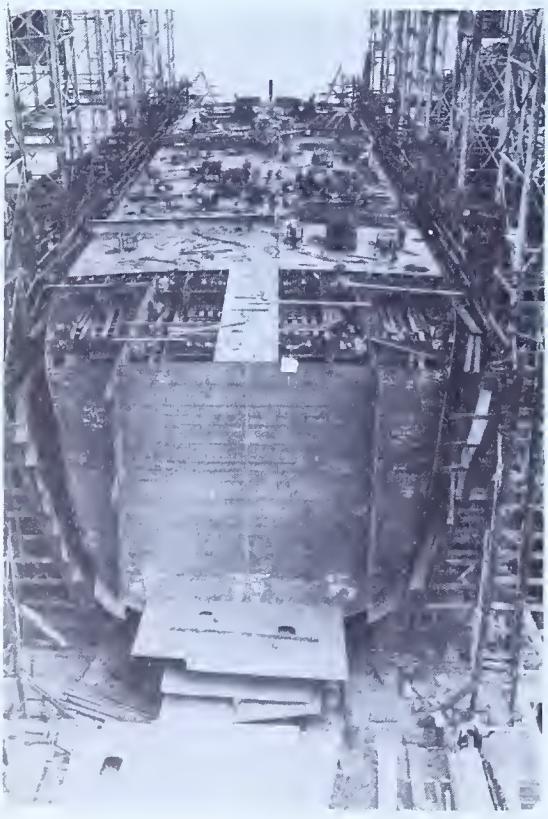
   Owing to the added facilities offered by the shipway, it is feasible to install all possible equipment before launching.
7. *Afloat after Launching*--The ship is being taken to its berth in the wet basin, where outfitting will be completed.
8. *Eighteenth Week*--After completion and trial trip, the vessel is delivered to her owners.



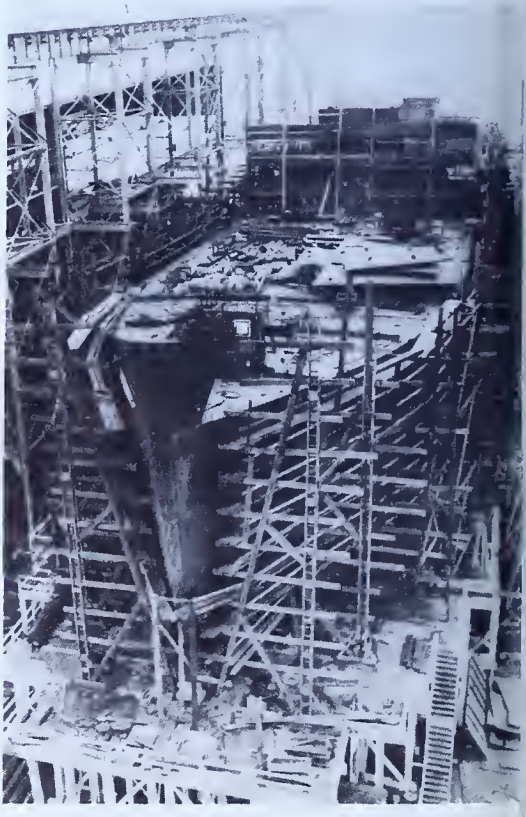
1 -- First Day



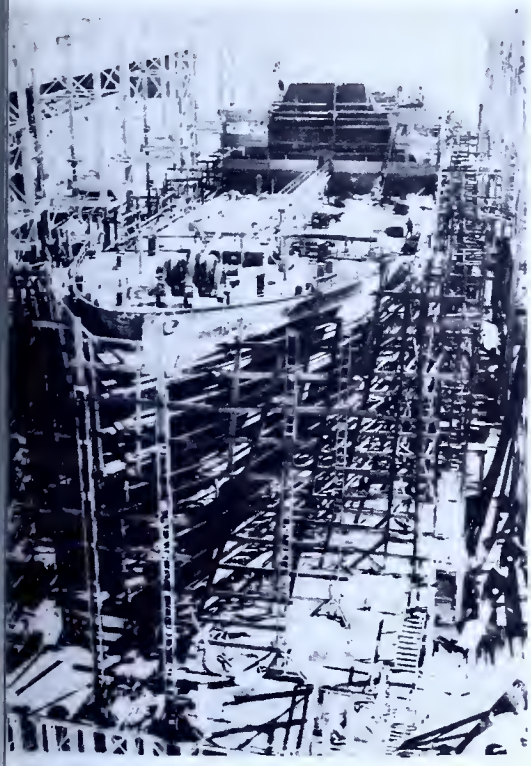
2 -- Second Week



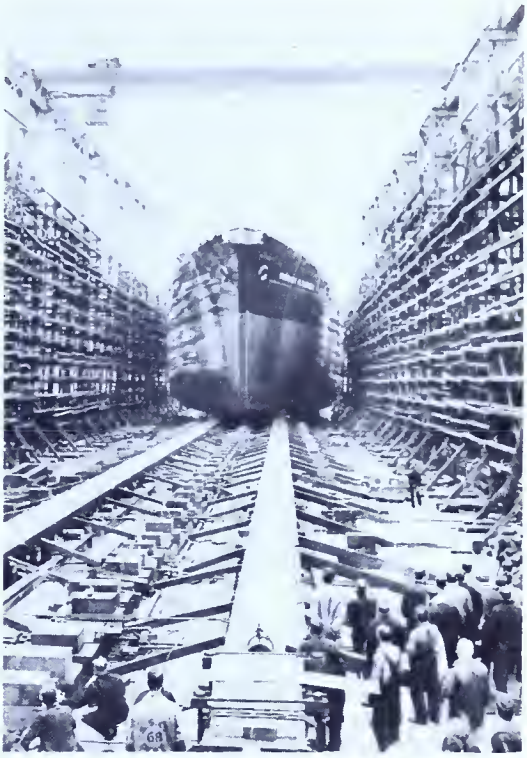
3 -- Eighth Week



4 -- Eleventh Week



5 -- *Fourteenth Week*



6 -- *Sixteenth Week*
(Launching)

7 -- *Afloat After Launching*

8 -- *Eighteenth Week*
(Delivery to Owners)

PART X

Developments and Intersections

LAYOUT FOR A ROLLED CYLINDER

Templates for many steel members such as conical foundations, cyclindrical pipes, and rectangular or irregular hollow sections, as well as intersections or various combinations of these, are made by development from an ordinary blue print of the members involved.

Shipfitters often have an occasion to perform such work, and should be thoroughly familiar with the principles involved.

The development of any surface is an expanded or flattened view; in other words, it is the appearance of the surface when unrolled or unfolded into a single plane. In making a cylindrical pipe or tube, it often is necessary to roll a flat plate and weld the edges together as illustrated at (A) in Fig. 208. One dimension of the plate as laid out is the length of the cylinder. The other dimension must be the circumference of the neutral surface of the rolled cylinder, or π times the diameter. In this case, it is π x 23" or 72-1/4".

The length of the neutral surface does not change when the plate is rolled. The inside surface contracts and the outside expands accordingly, so that the cylinder when rolled has an inside diameter of 22" and an outside diameter of 24".

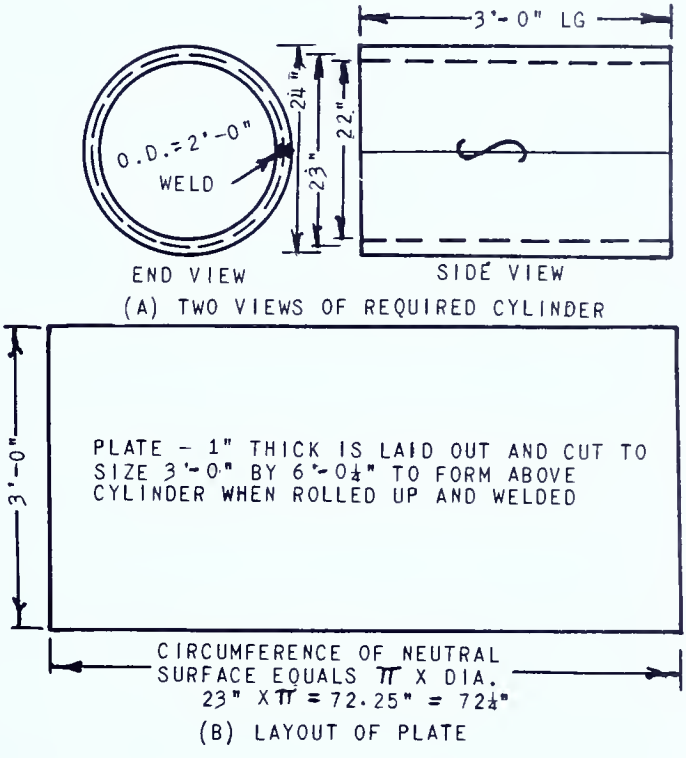

3'-0" LG
O.D.=2'-0"
WELD
24"
23"
22"
END VIEW
SIDE VIEW
(A) TWO VIEWS OF REQUIRED CYLINDER
3'-0"
PLATE - 1" THICK IS LAID OUT AND CUT TO SIZE 3'-0" BY 6'-0¼" TO FORM ABOVE CYLINDER WHEN ROLLED UP AND WELDED
CIRCUMFERENCE OF NEUTRAL SURFACE EQUALS π X DIA.
23" X π = 72.25" = 72¼"
(B) LAYOUT OF PLATE

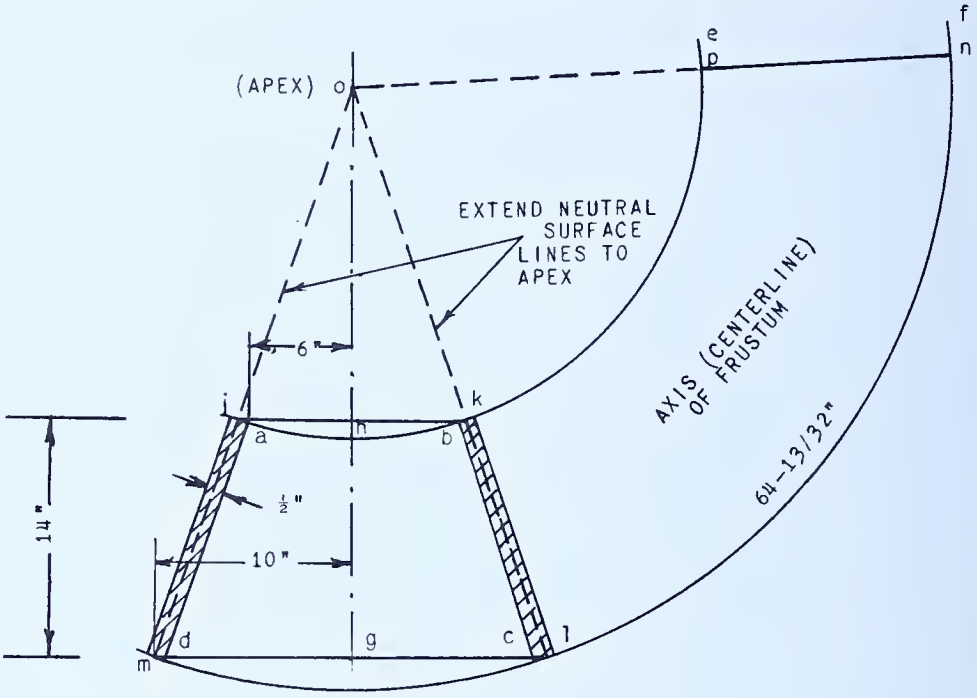
Fig. 208 -- Layout of Flat Plate for Rolling into a Cylinder

Question

1. What is the meaning of the symbol II?
2. What would be the result of developing the cylinder, using the inside of

LAYOUT FOR A FRUSTUM

The conical surface, or frustum shown in section view in Fig. 209 is to be developed and laid out on a flat plate. The inside radius of the base is 10". The inside radius of the top is 6". The height is 14", and the plate thickness is 1/2". The neutral surface of the plate is at its center of thickness. In developing the plate, we flatten out this neutral surface and lay it out on the flat plate. This plate then takes the proper shape when rolled.



RADIUS AT BASE = 10" INSIDE
RADIUS AT TOP = 6" INSIDE
THICKNESS OF PLATE: ½"
LENGTH OF (ALONG CIRCLE) = 20.5 x 3.1416 = 64.4028 = 64-13/32"

Fig. 209 -- How to Develop a Frustum

How to Develop a Frustum

Using the dimensions given in the blue print, lay out to full scale, the vertical section through the frustum.

(The vertical section is a view showing a cut through the frustum, and including the axis or centerline as illustrated in Fig. 209.)

The indicated neutral surface will then be developed by expanding the whole cone of which the frustum is a part.

The detailed procedure is as follows:

PROCEDURE

1. On a piece of template paper draw a horizontal line to represent the inside diameter of the base of the frustum. In the example given, Fig. 208, *this will be* the line "dc", which is 20" long (inside diameter of base).

. Erect a perpendicular bisecting the line "dc". This will be the axis or centerline, "og", of the conical surface.

. On the perpendicular, lay off the height of the frustum, "gh". In the example given, this height is 14".

. Through point "h" (a point where the axis or perpendicular passes through the top of the frustum) draw the top surface of the frustum parallel to the bottom surface. In the example given, this is "ab", whose length is 12" (inside diameter of the top).

. Draw lines "bc" and "a-d", which represent the sloping inside surface of the frustum.

. Lay out the thickness of plate on the outside of "ad" and "bc". The measurement must be made perpendicular to "ad" and "bc" (1/2" in this example).

. At the center of thickness of the plating, draw the neutral surface lines, "mj" and "lk", extending these lines to their intersection "o" at the apex of the cone.

. With the apex of the cone as the center point, and using the distance "om" (from the apex to the base at neutral surface of the plate) as a radius, draw the arc "mlf", as illustrated.

. Using the apex "0" as a center, and using "oj" as a radius, draw the arc "jke".

9. Calculate the circumference of the base of the frustum at the neutral surface.

The required length of the neutral surface at the base is found as follows:

$$\begin{aligned} \text{Circumference} &= \text{Diameter} \times \pi \\ \text{Diameter} &= 10" + 10" + \tfrac{1}{4}" + \tfrac{1}{4}" \\ &= 20\tfrac{1}{2}" \\ \text{Circumference} &= 20\tfrac{1}{2}" \times 3.1416 \\ &= 64.4028 \\ &= 64\ \tfrac{13}{32}" \end{aligned}$$

0. Measure along arc "mlf" to calculated circumference ($64\ \frac{13}{32}$" in this example).

This distance may be accurately measured along a circular arc by use of a flexible steel tape, or a thin wooden batten placed on edge.

1. Draw a straight line connecting the apex "0" and point "n", cutting the arc "jke" at "p".

The template "jkpnlm", gives the shape which must be cut from a flat 20.4# plate to roll into a frustum of the required size. Such a development is used in making a conical foundation for a fairlead, or a mushroom type ventilator head.

Questions and Problems

1. Why is the neutral surface used in developing the frustum?
2. How is the circumference of a circle found, when the radius is given? When the diameter is given?

3. Develop a template for a fairlead base, the specifications of which are as follows:

   Inside diameter of base, 3'-0"; inside diameter of top, 1'-6"; height 2'-6"; plating thickness 5/8". After development is completed, allow 1" of stock, at base of fairlead for scribing.

LAYOUT FOR A CYLINDER WITH SLOPING TOP

"Parallel line development" is used in laying out a flat plate which is to be rolled into a cylinder having a sloping top as illustrated in Fig. 210. This development also, will be at the neutral surface, or center of thickness.

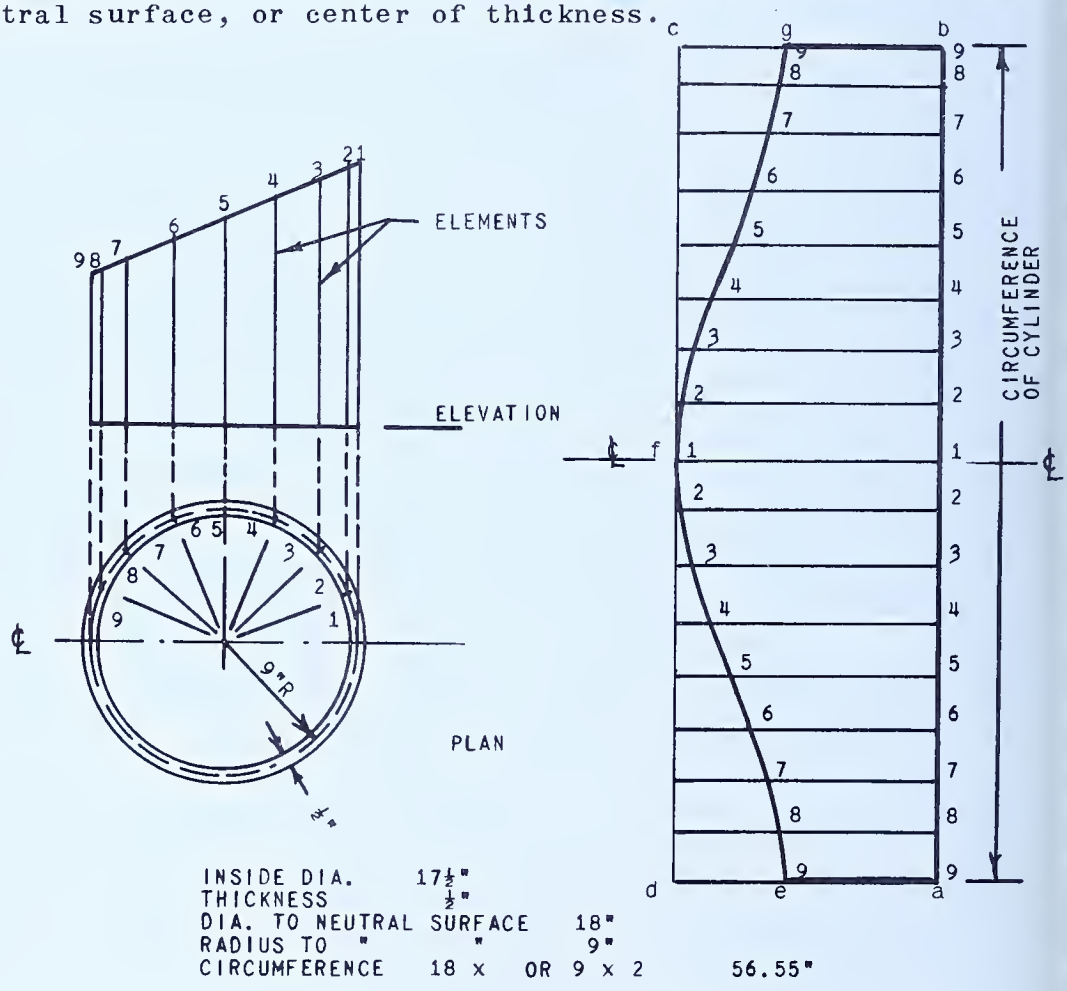


Fig. 210 -- Layout For Cylinder With Sloping Top

Inside dia. = 17½"
Thickness = ½"
Dia. to neutral surface = 18"
Radius to " " = 9"
Circumference 18 x π or 9 x 2π = 56.55"

The diameter of the cylinder is *18" to the neutral surface.* This cylindrical surface must be unrolled, or opened into a flat surface. The bottom, or base, is in a plane perpendicular to the

axis of the cylinder. This base will therefore open up into a *straight line*. This is the line "ab" of the template at the right. (Its length is 3.1416 x 18" or 56.55").

The plan view (circle) is then divided along the circumference into any number of equal spaces. Each dividing mark in the plan view (1, 2, 3, etc.,) represents a vertical line in the elevation. These lines, parallel to the axis of the cylinder, are called *elements* of the surface. The elements are all equally spaced along the circumference.

The length of the line "ab" (which is the circumference) is now laid off as shown on the template. It is divided into 16 equal parts, and the elements of the cylinder are laid out perpendicular to "ab" as shown. "Cd" is parallel to "ab" at such a distance that "ad" and "bc" are equal in length to the longest element (1) in the elevation. This longest element gives the maximum width of the template.

The lengths of the various elements are picked up consecutively from the elevation and laid out in the proper order on the template. A fair line "efg" is then drawn through the extremities of the elements to give the developed shape of the top of the cylinder. The template "abgfe" now represents the cylindrical surface and can be used to lay out a flat plate to be rolled to this shape.

LAYOUT FOR RIGHT-ANGLE INTERSECTION OF TWO CYLINDERS

Parallel line development is, also, used in making a template for the intersection of two cylinders of different diameter, as shown in Fig. 211.

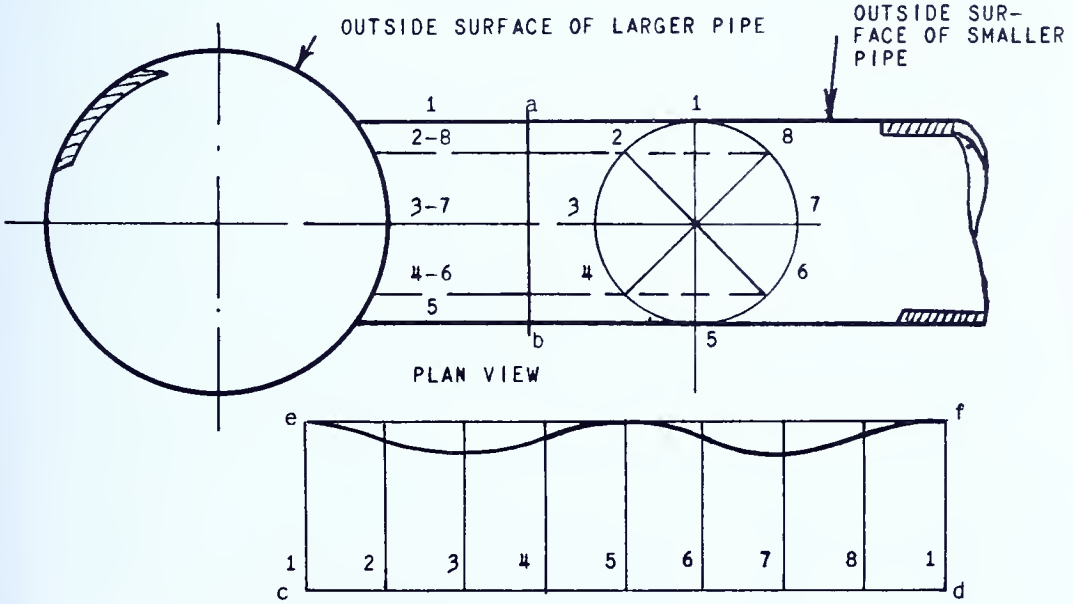


Fig. 211 -- Template for Intersection of Two Cylinders

When developing this intersection, equally spaced elements are drawn in, parallel to the axis of the smaller pipe, and intersecting the larger cylinder. (That is, the elements are *equally spaced around the circumference* as in the preceding figure).

A reference line "ab" is drawn in perpendicular to the axis. Lengths of the elements are measured from this line, since the small pipe may be indefinitely long.

To make the template for the shape of the end of the smaller pipe a line "cd" is drawn, equal in length to the circumference of the smaller pipe.. The elements are drawn in equally spaced and perpendicular to "cd" as shown. The length of each element is obtained by measuring from line "ab" to the large circle in the plan view. A fair line "ef" is drawn in through the ends of the elements. The template can then be cut along this fair line and wrapped around the smaller pipe, giving the shape to which it must be burned.

For large cylinders which must be rolled up out of a flat plate, the same method can be used, except that the neutral surface of each cylinder is used rather than the outside surface.

APPLICATION OF PARALLEL LINE DEVELOPMENT TO HULL CONSTRUCTION

An offset cylindrical ventilator, 24" outside diameter, is to be rolled up from 3/8" steel plate, as illustrated in Fig. 212. The layout is made on a wooden floor as shown, starting with the center line "abcd", This line can be determined from the drawing.

Since the outside diameter is 24" and the plate thickness is 3/8", the neutral surface diameter is 23-5/8" and the radius is 11-13/16". The lines "efgh" and "ijkl" are then drawn in 11-13/16" from the center line. It can now be seen that the ventilator must be made in three pieces, with the joints at "fbj" and "gck".

To make a template for the top piece, a line "mn" is drawn to represent the base or circumference at "ei". The length of this circumference is π x 23-5/8" or 74.22".

A circle is drawn in the top piece as shown and elements are drawn in at equal intervals around this circle. The line "mn" is then divided into the same number of equal spaces and the elements drawn in on the template. Lengths of all these elements are obtained by measuring from the under side of the top deck to the intersection line at "fj".

The template "mnop" may now be used to lay out a 3/8" steel plate to be rolled into a cylinder to form the top piece of the ventilator. The seam can be welded tight.

Templates for the other two pieces are similarly made, except that for the middle piece a line "qr" is drawn perpendicular to the axis for use as a reference line in laying out the elements for the template. Measurements are taken from this line up to the top intersection and, also, from "qr" down to the bottom intersection. (It should be noted that the same template may be used

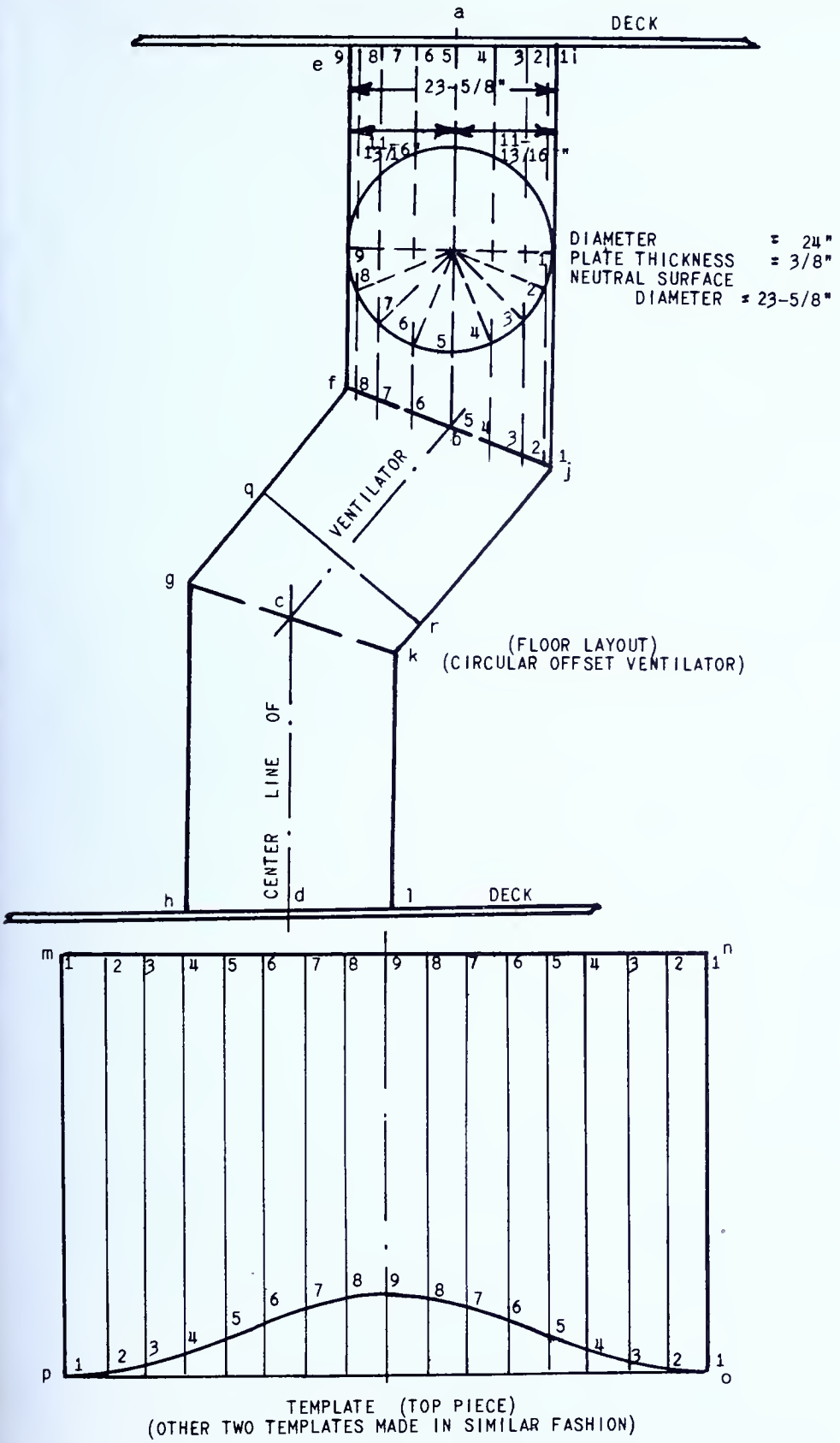


Fig. 212 -- Development of Cylindrical Offset Ventilator

for all four cuts in this case by taking care that the lengths of the three sections are correct, and that the template is used in two exactly opposite directions when laying out the middle piece of pipe. This would apply in all cases where the angle of the cut is the same.)

DIVIDING A LINE INTO ANY NUMBER OF EQUAL PARTS

Fig. 212 illustrates the method used to divide a line into any number of equal parts.

In the example given, the line "ab" is 6'-0" long and must be divided into seven equal parts. Each part must be 6/7 of a foot long, which makes it slightly over 10" long, but hard to calculate and measure with a rule. The line "ac" is drawn in at *any angle* with "ab". Starting at "a", lay off seven equal distances "ah", "hj", etc. These lengths should be such, that "ac" approximately equals "ab". A line is drawn from "c" to "b", and the lines "de", "fg", etc. are drawn from the marks on "ac" and *parallel* to "cb". These lines will divide "ab" into seven equal parts.

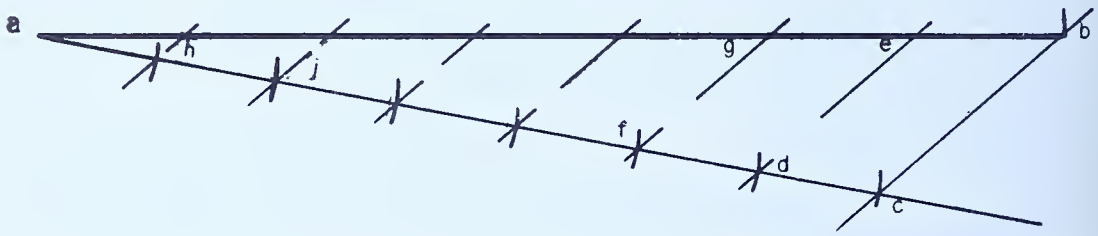


Fig. 213 -- Dividing a Line into Any Number of Equal Parts

PROCEDURE

1. Draw line "ac" at an angle from "ab".
2. Lay off seven equal divisions on "ac".
3. Draw "cb".
4. Draw "de", "fg", etc. parallel to "cb".
5. Line "ab" will then be divided into seven equal parts.

LAYOUT OF A CAMBER CURVE

The transverse deck curvature, or camber curve, is often, *but not always*, a circular arc with a large radius. To lay out this curve, for a bulkhead, beam, or other member, the following construction can be used.

In Fig. 214, the width of the deck is "ab" and the camber height at center is "cd". *A circular segment must be drawn through a, d, and b.*

The radius for a camber curve is usually so long that the center of curvature is not accessible.

With "a" and "b" as centers, arcs "bf" and "ae" are drawn as shown. "Ad" and "bd" are extended to "g" and "h". Arc "ah" is

divided into any number of equal parts, and the marks are numbered as shown 1, 2, and 3. Equal divisions are laid off on "gf" and numbered 1', 2', and 3' as illustrated.

To find a point on the required circle, a line is drawn from "a" to 3'. This line intersects at "p3" a line drawn from 3 to "b". "P3" is the required point. The intersections of other straight lines drawn respectively from "a" and "b" to the corresponding numerals, give the other points on the circle from "a" to "d".

The arc from "d" to "b" is obtained in a similar manner, using points, 4, 5, 6, and 4'; 5'; and 6'.

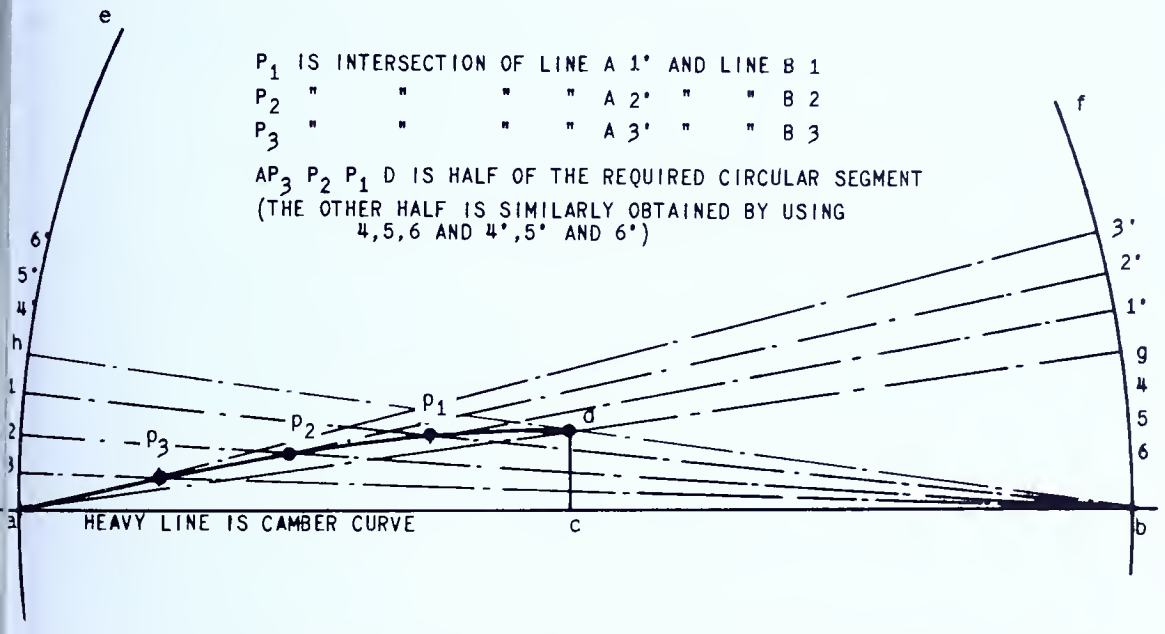


Fig. 214 — Laying Out a Camber Curve or Other Circular Segment of Large Radius

CONSTRUCTING AN ELLIPSE

A method commonly used by shipfitters in laying out an ellipse is illustrated in Fig. 215.

The major axis of the ellipse is "ab"; the minor axis is "cd". When the lengths "ab" and "cd" are known, a wooden batten is marked off with points "e", "f", and "g", such that the distance "eg" equals half the major axis and "fg" equals half the minor axis. The batten is moved around to various positions, keeping point "f" always on the major axis and keeping point "e" always on the minor axis. The point "g" will then trace out the curve of the oval; i.e., true ellipse, as illustrated. Any number of points can be obtained this way, and a fair curve drawn through them. The more points used, the more accurate will be the ellipse. For very small ovals, a strip of paper can be used instead of the wooden batten.

The following method of constructing an oval is useful to a shipfitter in laying out the proper curve of intersection when a pipe or other cylinder passes obliquely through a flat surface, such as a deck or bulkhead, as illustrated in Fig. 216. An oval is laid out on the deck plate with the minor axis equal to the diameter of the pipe. The major axis, as illustrated in Fig. 216, is found by making a full scale layout of a section through the pipe at the deck, as shown. If the deck is not too thick the oval is burned out as illustrated, and the tapered openings welded.

For heavier deck plates, instead of making vertical cuts as shown, the tip of the torch is held parallel to the center line of the pipe, this making a neater fit around the outside surface of the pipe.

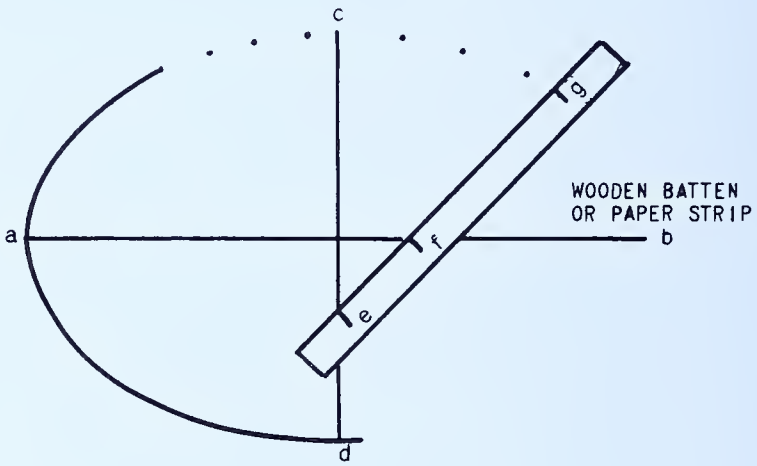


Fig. 215 -- Construction of Ellipse (Oval)

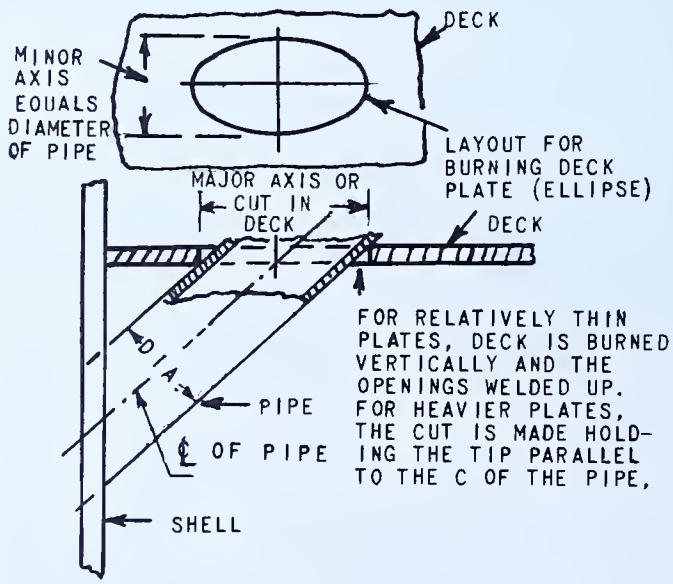


Fig. 216 -- Deck Layout for Intersection of Oblique Pipe

CUTTING HAWSE PIPE DECK INTERSECTION WITH SLIDING CIRCLE TORCH

Figure 217 shows another practical method of burning a hole through a deck or shell plate to fit an inclined pipe. This method is especially useful in cutting a hole for a cylindrical hawse-pipe. In this case the plates to be cut are relatively thick.

The centerline of the pipe first is located at the deck and shell by means of dimensions taken from the drawing. A small hole is burned through at each spot and a small pipe or straight rod is tacked in place, as illustrated. This rod will represent the center line of the required pipe.

A circle torch is then mounted, as shown, on adjustable sliding brackets and set to the required radius. When burning the plate, the torch is rotated and at the same time advanced along the rod, so that, the hole will be neat and accurate. This torch is also used for burning the shell plate. (One piece should not be cut entirely away until the other piece has been almost cut out, so that the rod will be held in place until practically all the burning is done).

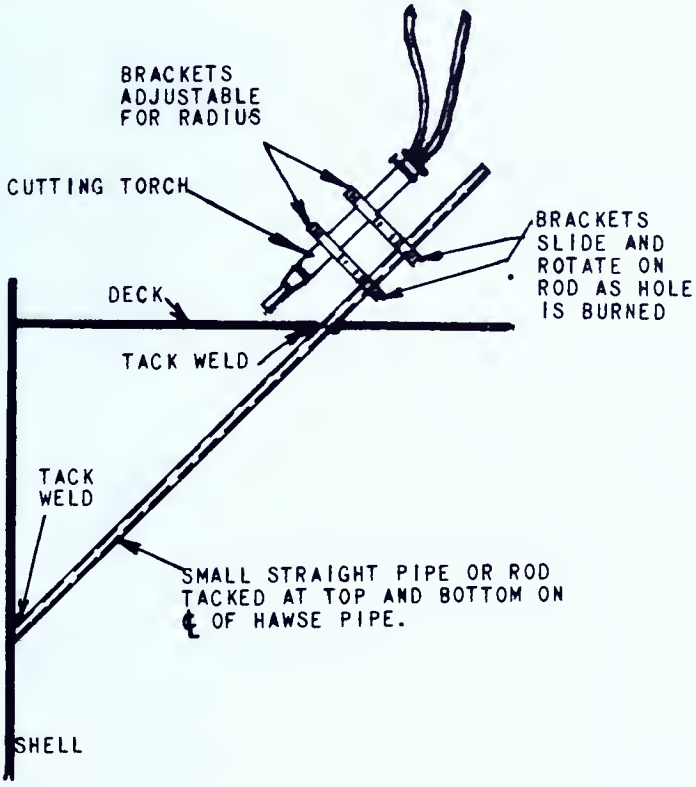

BRACKETS ADJUSTABLE FOR RADIUS
CUTTING TORCH
BRACKETS SLIDE AND ROTATE ON ROD AS HOLE IS BURNED
DECK
TACK WELD
TACK WELD
SMALL STRAIGHT PIPE OR ROD TACKED AT TOP AND BOTTOM ON ℄ OF HAWSE PIPE.
SHELL

Fig. 217 -- Use of Sliding Circle Torch in Cutting Hawse Pipe Deck Intersection

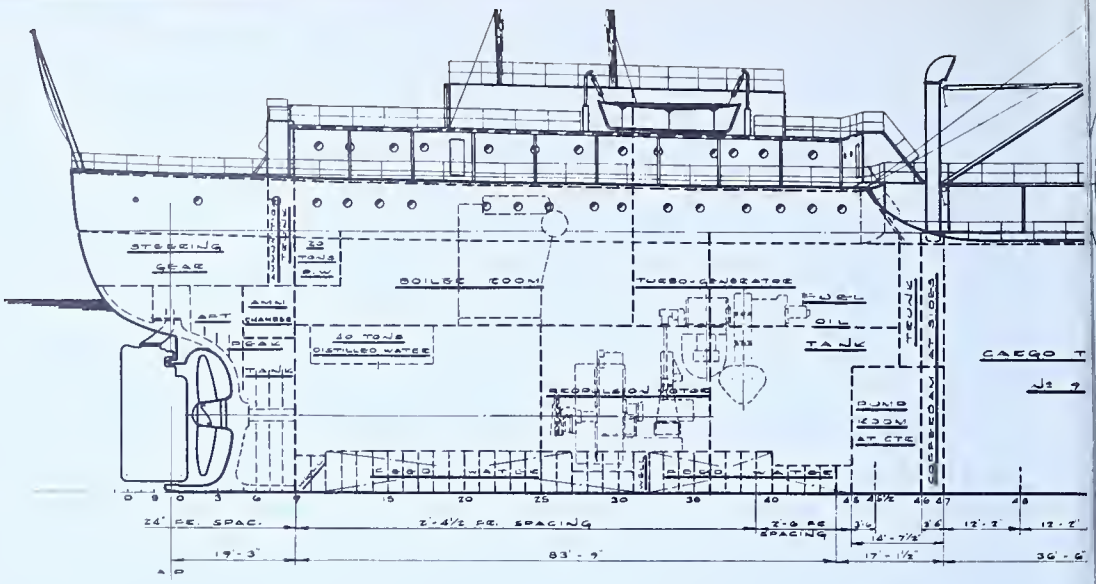
APPENDIX I

Typical Drawings Shipfitters Must Read

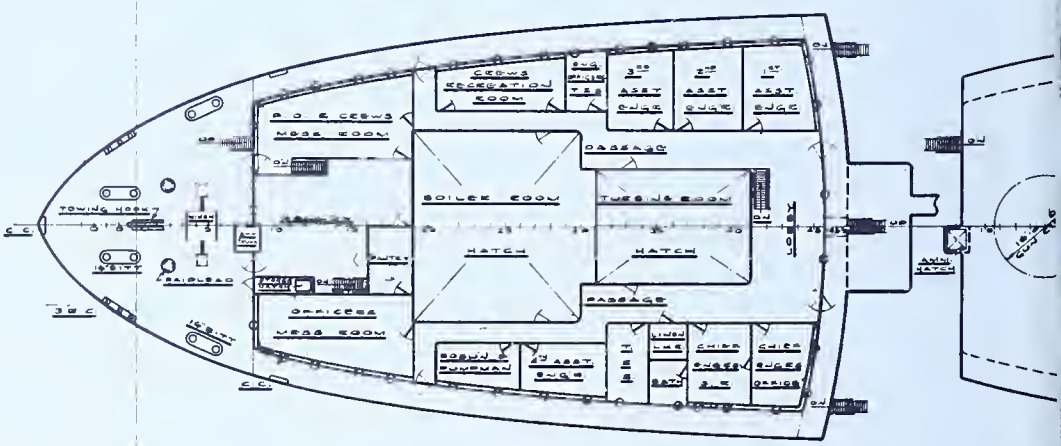
SPECIMEN DRAWINGS WHICH SHIPFITTERS ARE REQUIRED TO READ

Since all shipfitters are required to read hull blue prints, and in that this manual is not intended for comprehensive instruction in blue print reading, the following specimen prints are inserted so that the shipfitter trainee may develop an appreciation of the types of blue prints which he must learn to read as a part of his daily work.

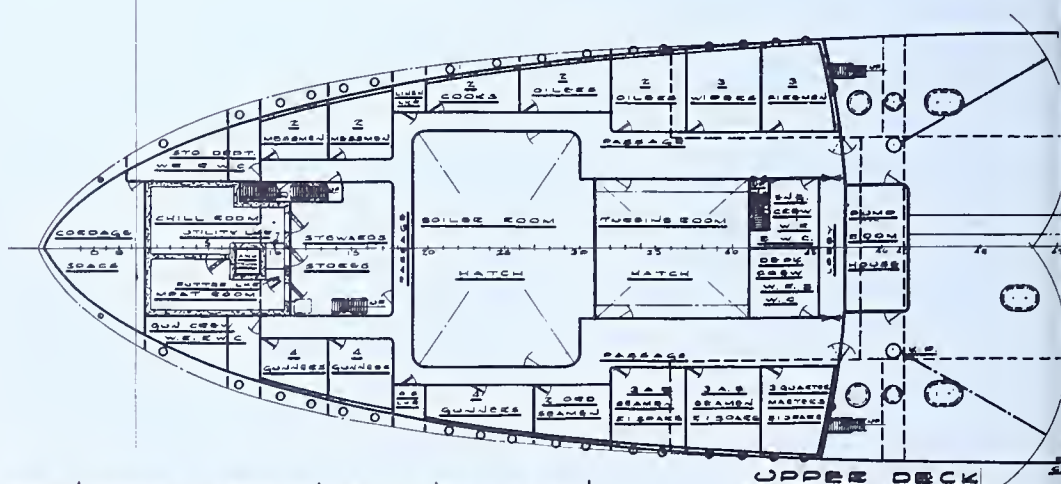
Following the hull drawings are questions pertaining to each print. These questions are typical of information which the shipfitter must obtain from blue prints. Each question may be answered from the prints herein reproduced. Most answers may be found from the specific print under which the question is listed, although a few require reference to related prints.



PROFILE

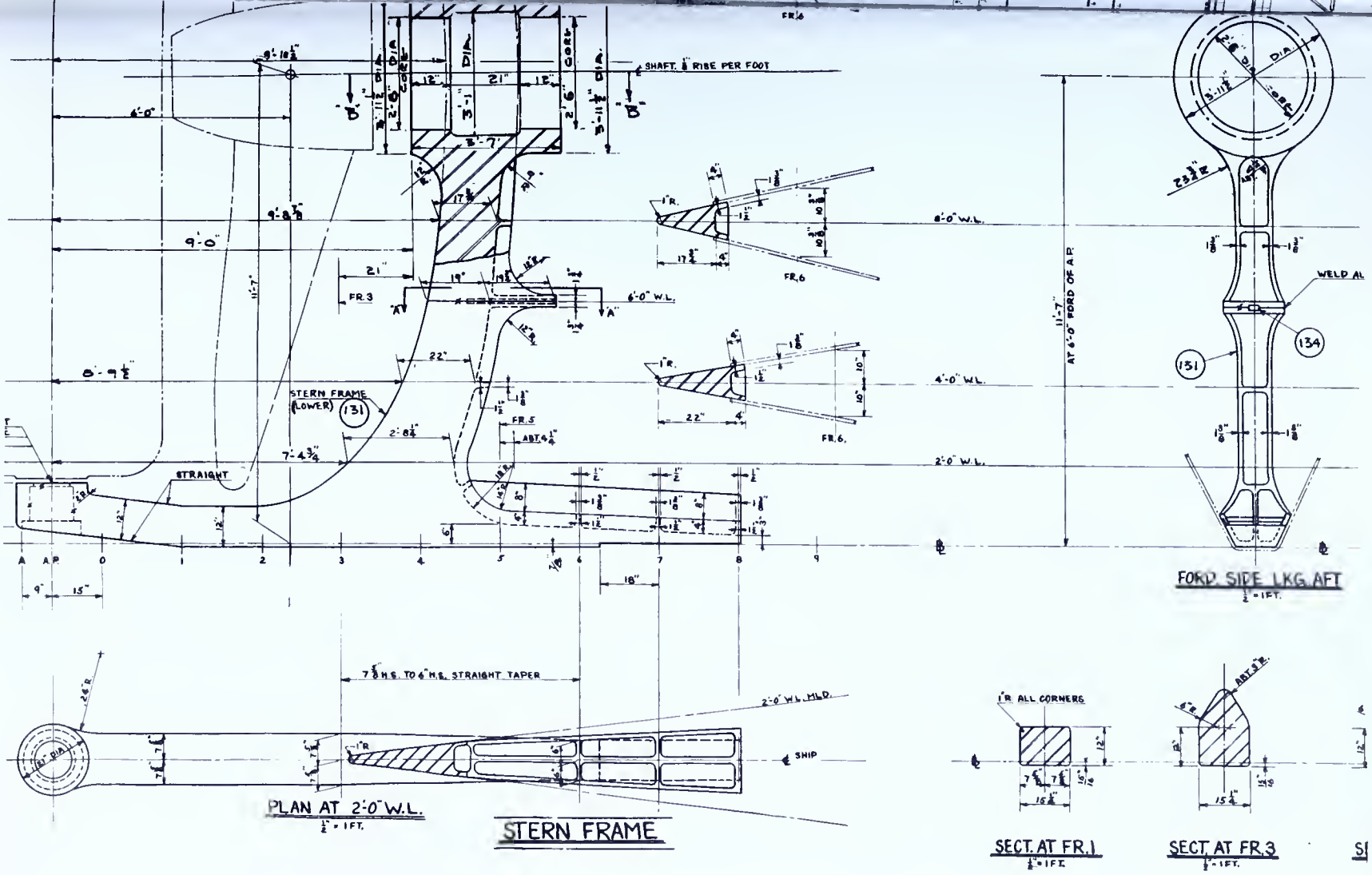


POOP DECK



UPPER DECK

GENERAL ARRANGEMENT PLAN



PLAN AT 2'-0" W.L.

1/2" = 1 FT.

STERN FRAME

FORD SIDE LKG. AFT

1/2" = 1 FT.

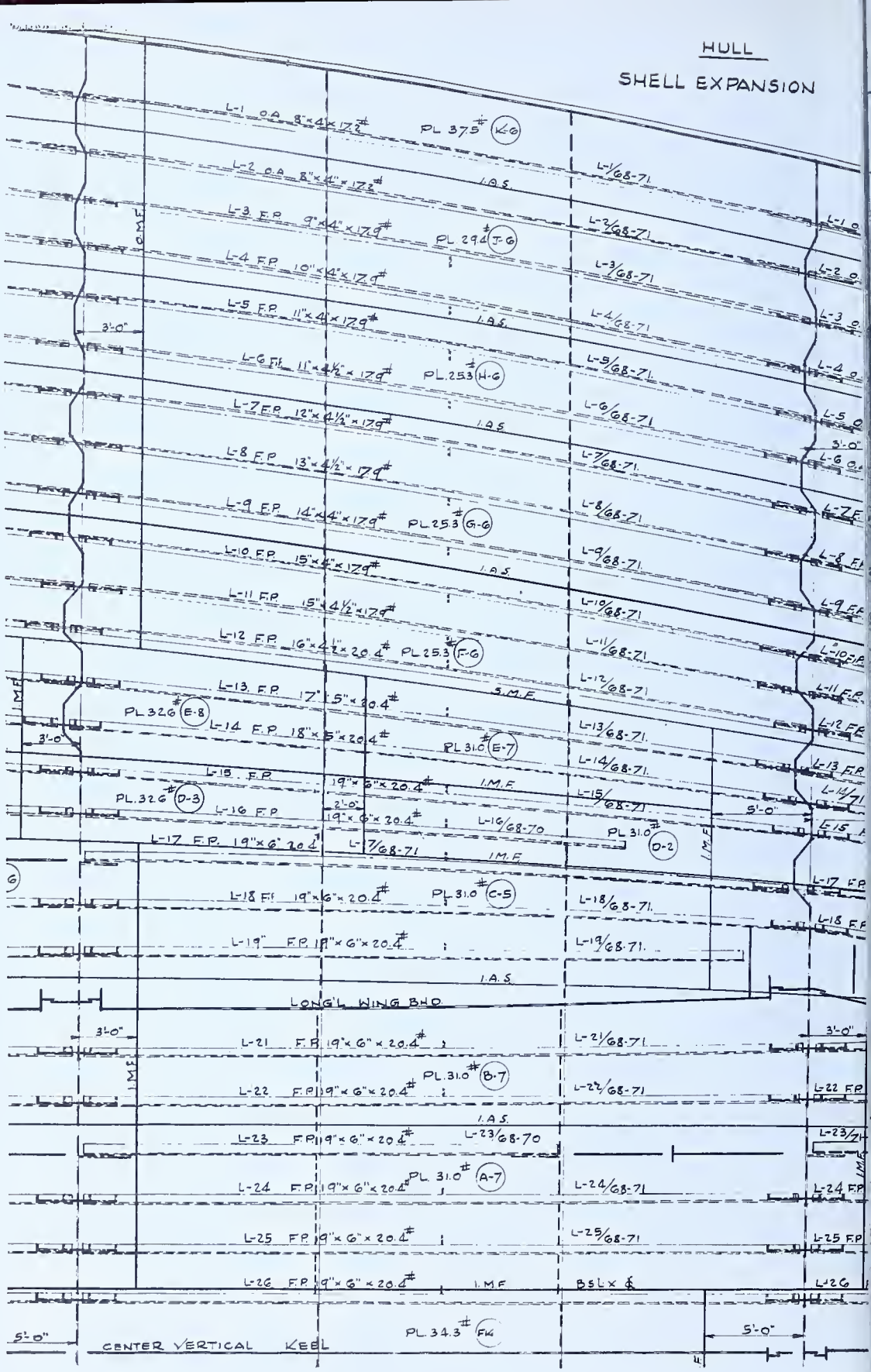
SECT. AT FR. 1

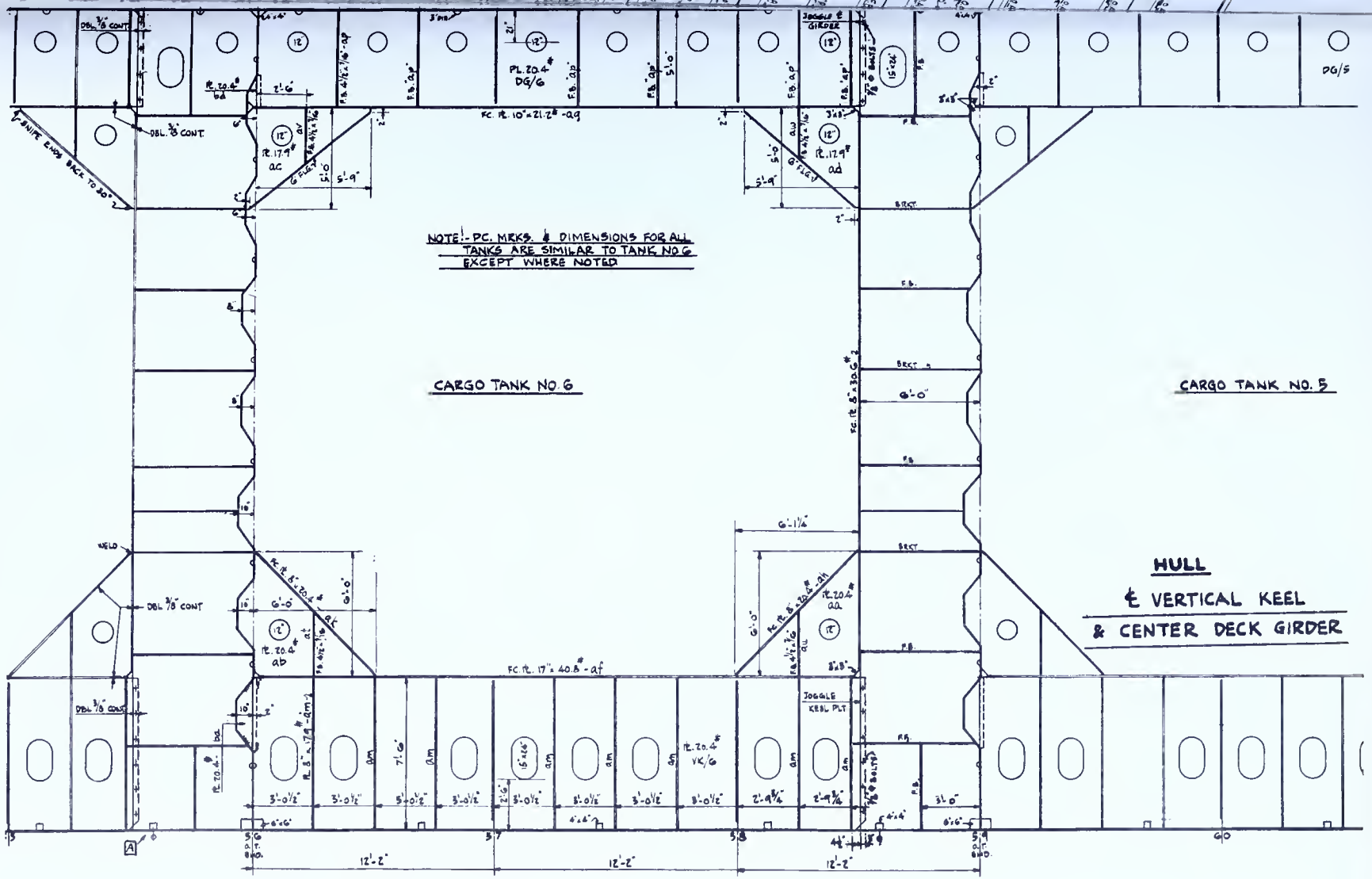
1/2" = 1 FT.

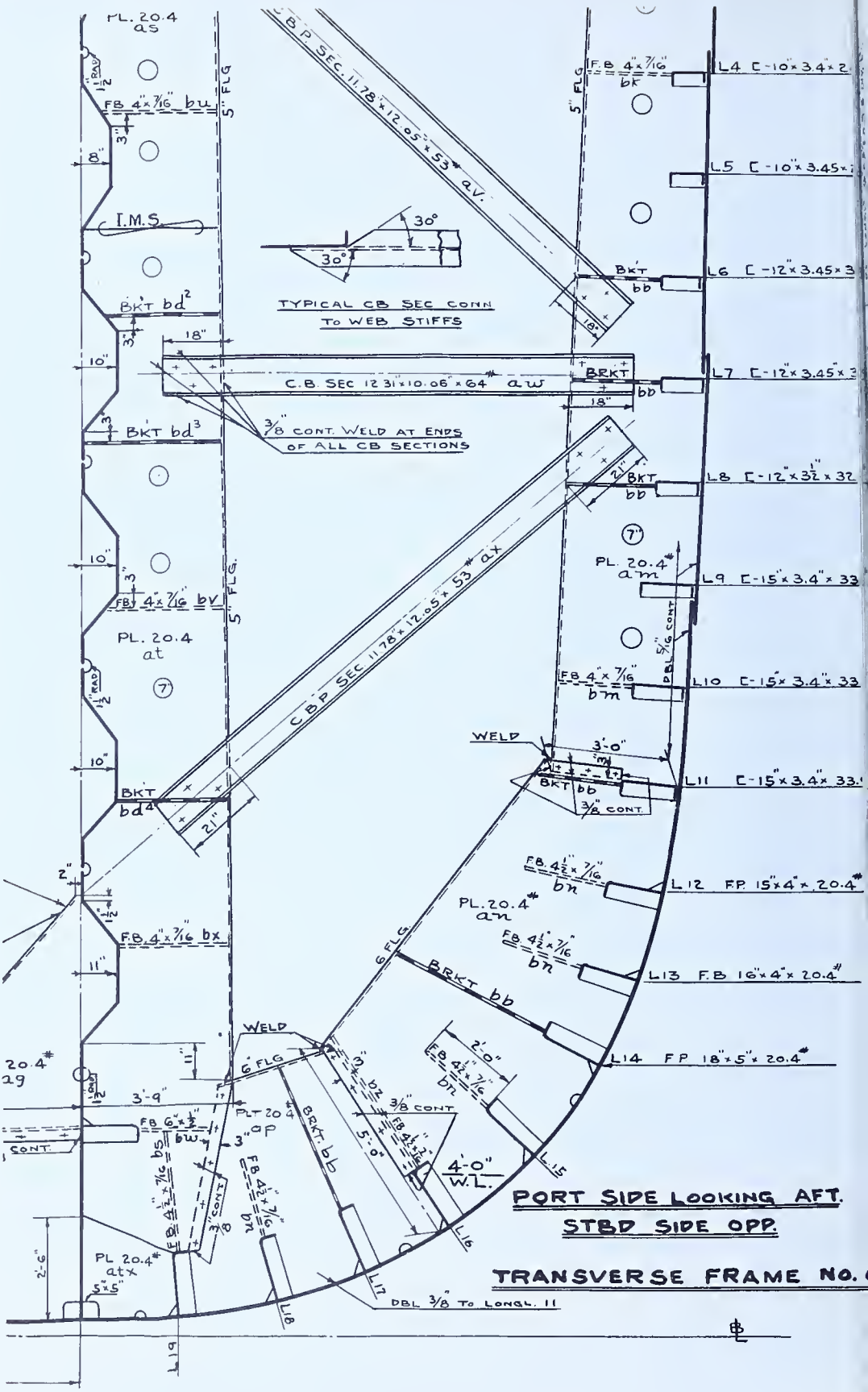
SECT. AT FR. 3

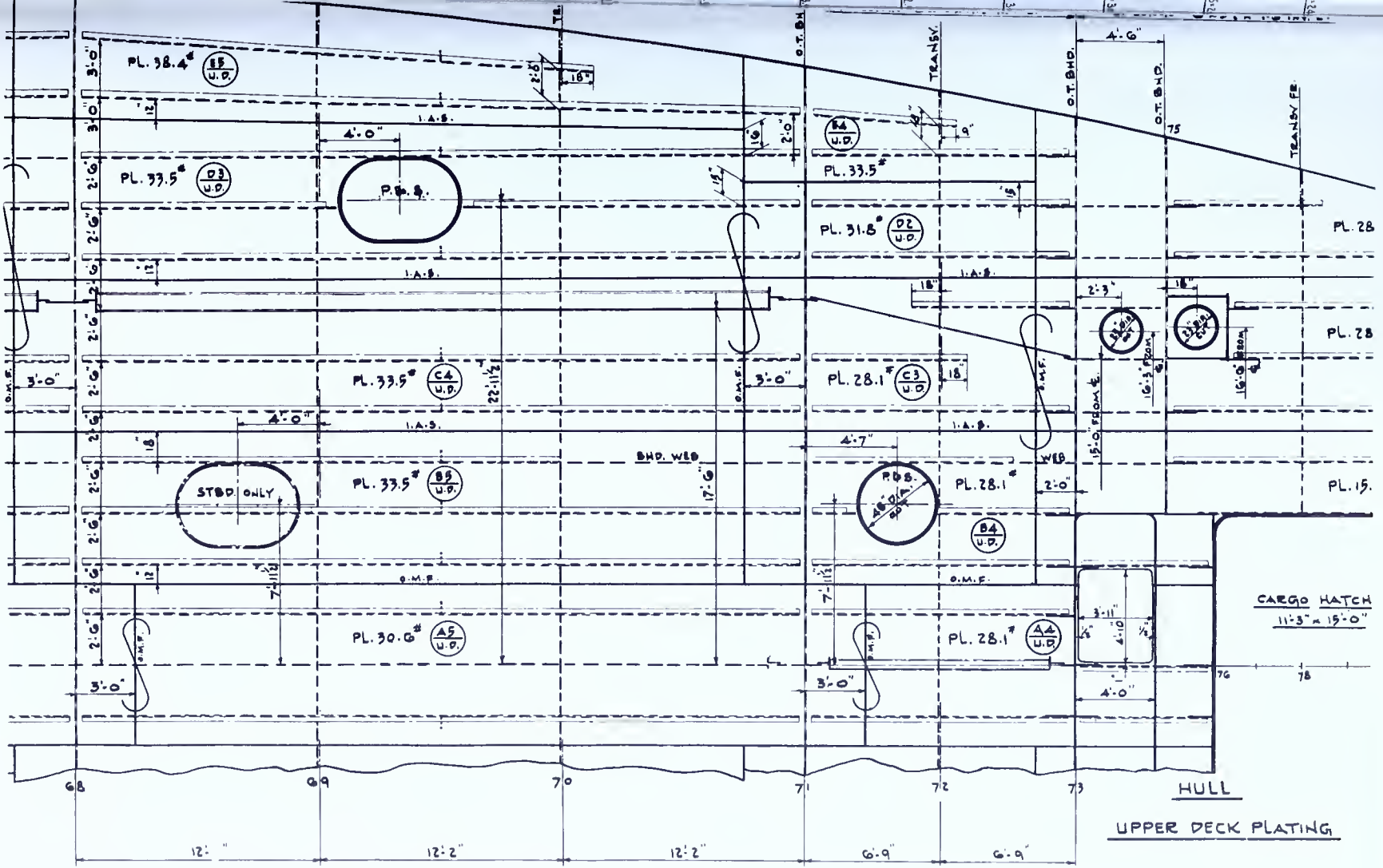
1/2" = 1 FT.

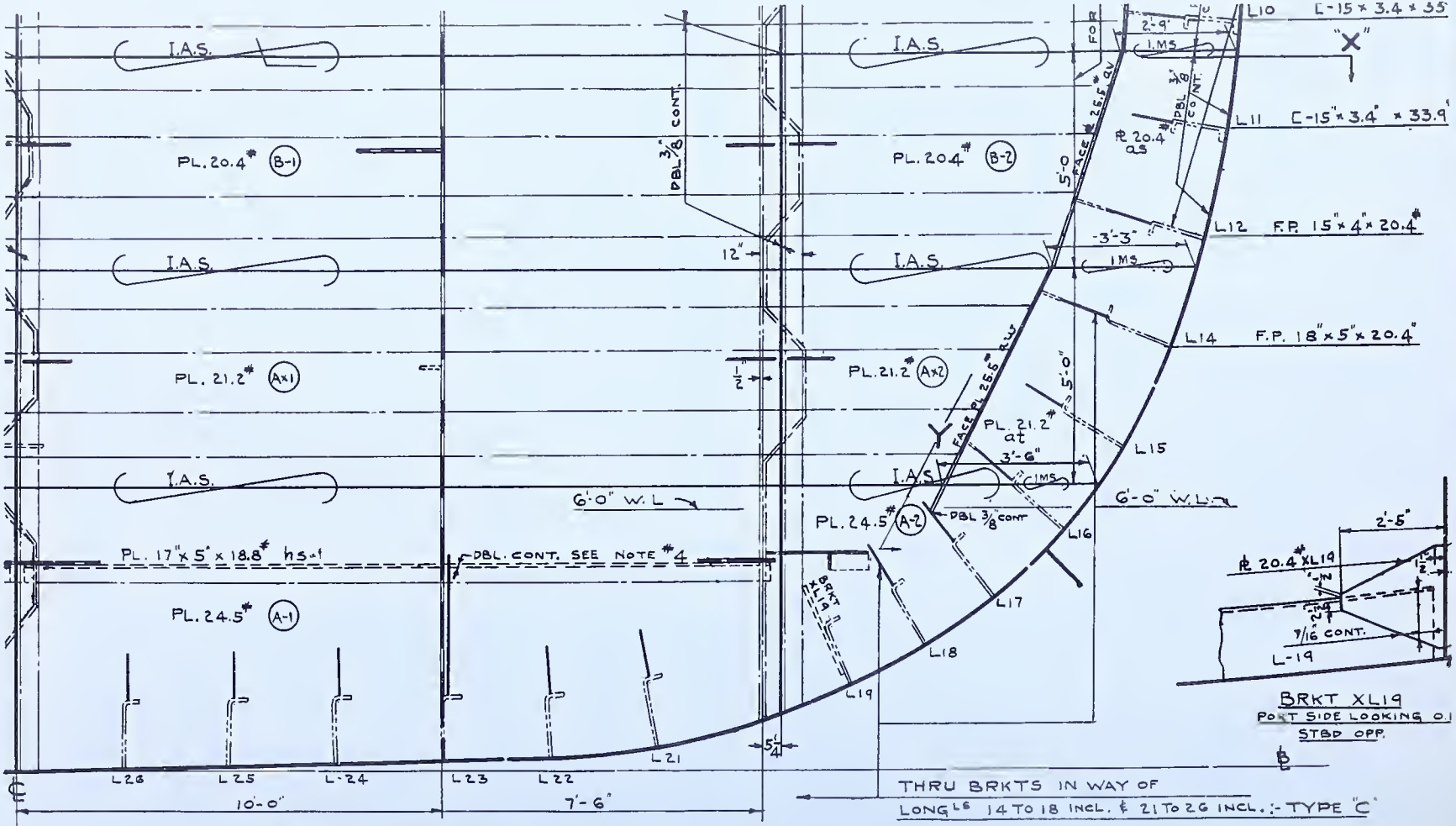
PRINT NO. 2, Page 211

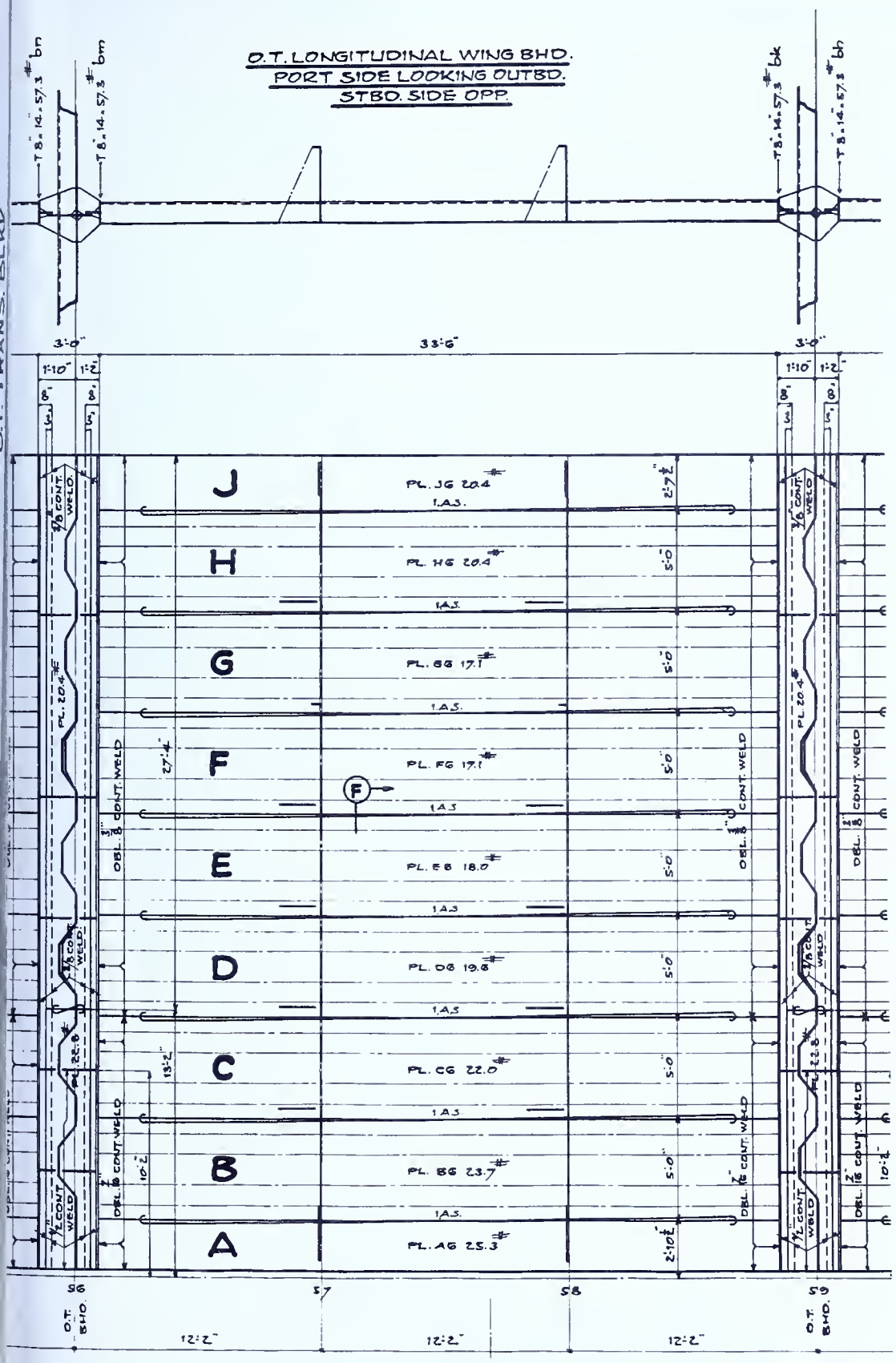

HULL
SHELL EXPANSION
L-1 O.A. 8"×4"×17.2#
PL 37.5# K-6
L-2 O.A. 8"×4"×17.2#
I.A.S.
L-3 F.P. 9"×4"×17.9#
PL 29.4# J-6
L-4 F.P. 10"×4"×17.9#
L-5 F.P. 11"×4"×17.9#
I.A.S.
L-6 F.P. 11"×4½"×17.9#
PL 25.3# H-6
L-7 F.P. 12"×4½"×17.9#
I.A.S.
L-8 F.P. 13"×4½"×17.9#
L-9 F.P. 14"×4"×17.9#
PL 25.3# G-6
L-10 F.P. 15"×4"×17.9#
I.A.S.
L-11 F.P. 15"×4½"×17.9#
L-12 F.P. 16"×4½"×20.4# PL 25.3# F-6
L-13 F.P. 17"×5"×20.4#
S.M.F.
PL 32.6# E-8
L-14 F.P. 18"×5"×20.4#
PL 31.0# E-7
L-15 F.P. 19"×6"×20.4#
I.M.F.
PL 32.6# D-3
L-16 F.P. 19"×6"×20.4#
L-16/68-70
PL 31.0# D-2
L-17 F.P. 19"×6"×20.4#
L-17/68-71
I.M.F.
L-18 F.P. 19"×6"×20.4#
PL 31.0# C-5
L-19 F.P. 19"×6"×20.4#
I.A.S.
LONG'L WING BHD
L-21 F.P. 19"×6"×20.4#
PL 31.0# B-7
L-22 F.P. 19"×6"×20.4#
I.A.S.
L-23 F.P. 19"×6"×20.4#
L-23/68-70
PL 31.0# A-7
L-24 F.P. 19"×6"×20.4#
L-25 F.P. 19"×6"×20.4#
L-26 F.P. 19"×6"×20.4#
I.M.F.
BSL×℄
PL 34.3# FW
CENTER VERTICAL KEEL
3'-0"
5'-0"

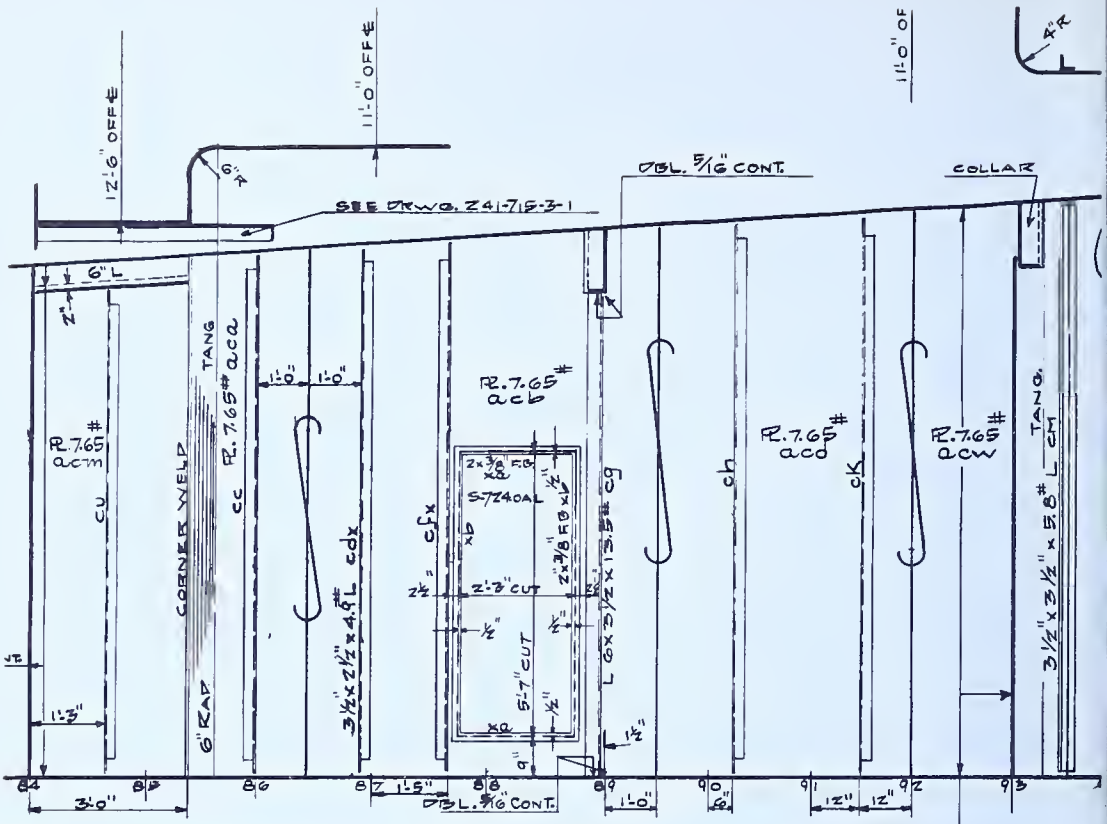

NOTE:- PC. MRKS. & DIMENSIONS FOR ALL TANKS ARE SIMILAR TO TANK NO 6 EXCEPT WHERE NOTED
CARGO TANK NO. 6
CARGO TANK NO. 5
HULL
& VERTICAL KEEL
& CENTER DECK GIRDER
DBL. 3/8" CONT
WELD
12'-2"
12'-2"
12'-2"

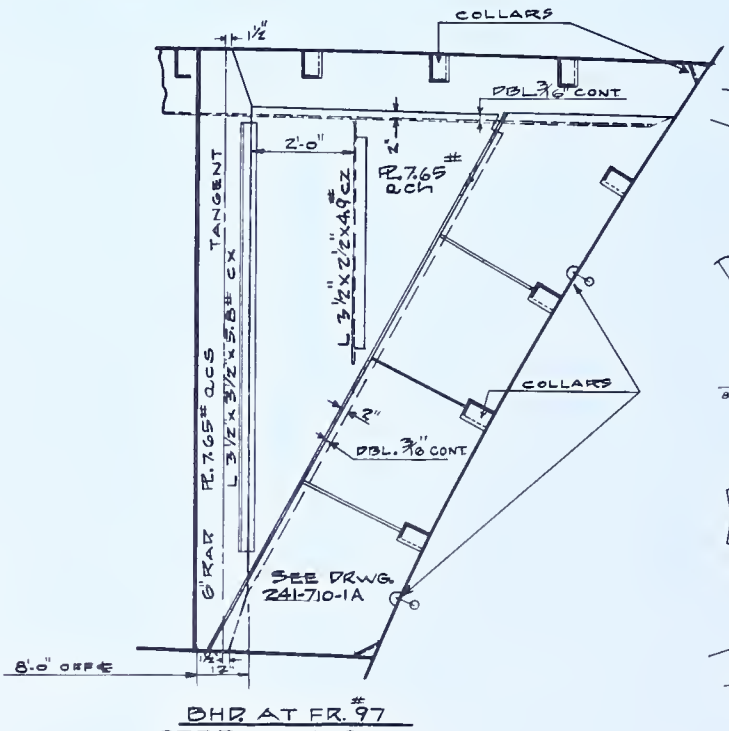

PL. 20.4 as
C.B. SEC. 11.78 x 12.05 x 53# av.
F.B 4" x 7/16" bu
I.M.S
30°
TYPICAL CB SEC CONN TO WEB STIFFS
BKT bd2
BKT bd3
C.B. SEC 12.31 x 10.06" x 64# aw
3/8" CONT. WELD AT ENDS OF ALL CB SECTIONS
BKT bd4
C.B.P. SEC 11.78" x 12.05" x 53# ax
PL. 20.4 at
F.B 4" x 7/16" bv
F.B 4" x 7/16" bx
PL. 20.4 ay
PL. 20.4 atx
PL. 20.4 am
F.B 4" x 7/16" bk
L4 C-10" x 3.4" x 2
L5 C-10" x 3.45" x
L6 C-12" x 3.45" x 3
L7 C-12" x 3.45" x 3
L8 C-12" x 3 1/2" x 32
L9 C-15" x 3.4" x 33
L10 C-15" x 3.4" x 33
L11 C-15" x 3.4" x 33.
F.B 4" x 7/16" bm
F.B 4 1/2" x 7/16" bn
L12 FP 15" x 4" x 20.4#
F.B 16" x 4" x 20.4#
L13
L14 FP 18" x 5" x 20.4#
L15
L16
L17
L18
L19
WELD
3/8" CONT.
DBL 5/16" CONT.
DBL 3/8" TO LONGL. 11
4'-0" W.L.
PORT SIDE LOOKING AFT.
STBD SIDE OPP.
TRANSVERSE FRAME NO.


PL. 38.4#
B5 U.D.
PL. 33.5#
D3 U.D.
P.O.S.
I.A.S.
4'-0"
PL. 33.5#
C4 U.D.
STBD. ONLY
PL. 33.5#
B5 U.D.
PL. 30.6#
A5 U.D.
O.M.F.
3'-0"
BHD. WELD
17'-6"
O.T. BHD.
TRANSV.
B4 U.D.
PL. 33.5#
PL. 31.8#
D2 U.D.
PL. 28.1#
C3 U.D.
4'-7"
P.O.S.
PL. 28.1#
B4 U.D.
PL. 28.1#
A4 U.D.
WELD
2'-0"
4'-6"
TRANSV. FR.
PL. 28
PL. 28
PL. 15.
CARGO HATCH
11'-3" x 15'-0"
68
69
70
71
72
73
74
75
12'-"
12'-2"
12'-2"
6'-9"
6'-9"
HULL
UPPER DECK PLATING

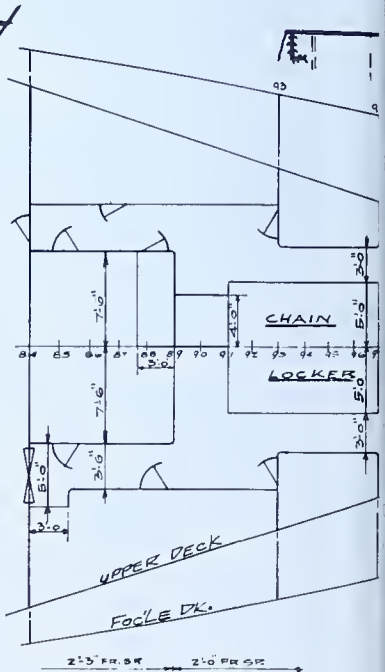

I.A.S.
PL. 20.4# (B-1)
PL. 20.4# (B-2)
PL. 21.2# (A-1)
PL. 21.2# (A-2)
PL. 24.5# (A-1)
PL. 24.5# (A-2)
PL. 17" x 5" x 18.8# hs-1
DBL. CONT. SEE NOTE #4
3/8" DBL CONT.
12"
1/2"
6'-0" W.L.
L10 L-15 x 3.4 x 35
"X"
L11 C-15" x 3.4" x 33.9#
R 20.4# QS
FACE PL 25.5# QV
5'-0
L12 F.P. 15" x 4" x 20.4#
3'-3"
1 MS
L14 F.P. 18" x 5" x 20.4#
PL. 21.2# at
3'-6"
L15
L16
L17
L18
L19
BRKT XL19
L21
L22
L23
L24
L25
L26
10'-0"
7'-6"
5/4
2'-5"
R 20.4# XL19
7/16" CONT.
L-19
BRKT XL19
PORT SIDE LOOKING O.T.
STBD OPP.
THRU BRKTS IN WAY OF LONGLS 14 TO 18 INCL. & 21 TO 26 INCL.:- TYPE "C"
BOTTOM SHELL LONGLS #15 TO #26 INCL. F.P. 19" x 5" x 20.4#
PORT SIDE LOOKING AFT
O.T. TRANS. BLKD


O.T. LONGITUDINAL WING BHD.
PORT SIDE LOOKING OUTBD.
STBD. SIDE OPP.
J
H
G
F
E
D
C
B
A
PL. JG 20.4
PL. HG 20.4
PL. GG 17.1
PL. FG 17.1
PL. EG 18.0
PL. DG 19.8
PL. CG 22.0
PL. BG 23.7
PL. AG 25.3
1.A.S.
56
57
58
59
O.T. BHD.
O.T. BHD.
12'-2"
12'-2"
12'-2"
33'-6"
3'-0"
3'-0"



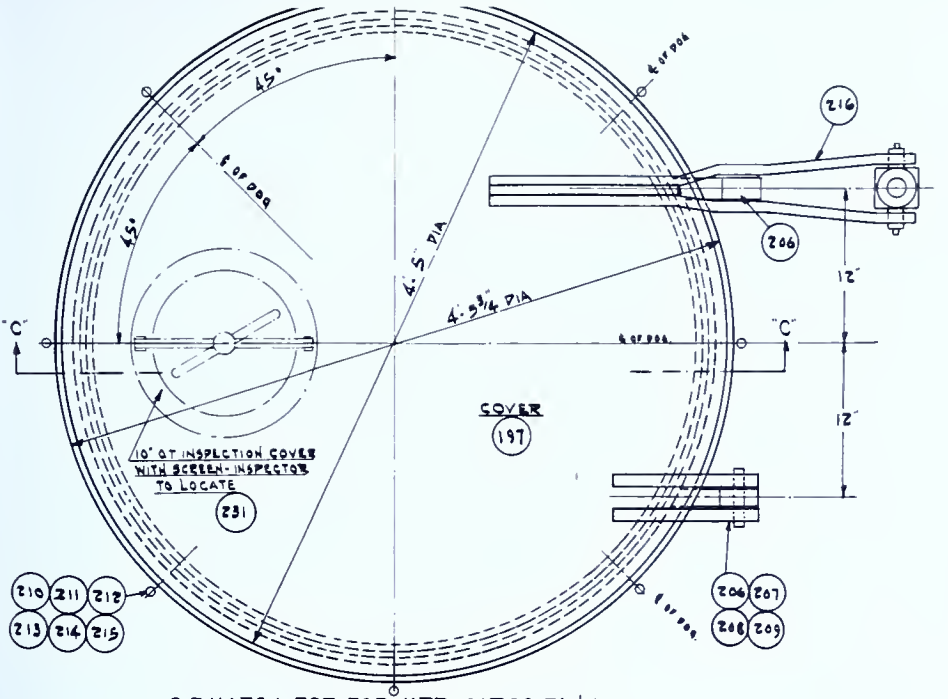


BHD AT FR. 97
STBD LOOKING FWD
PORT OPPOSITE

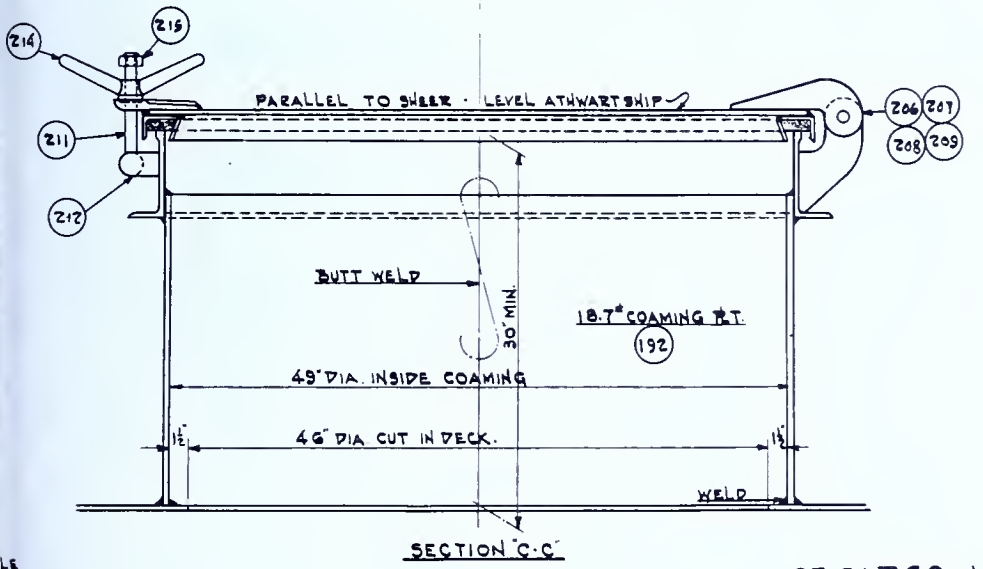


PLAN OF UPPER DK. FWD.

BHDS. ON UPPER DECK-FORWARD-

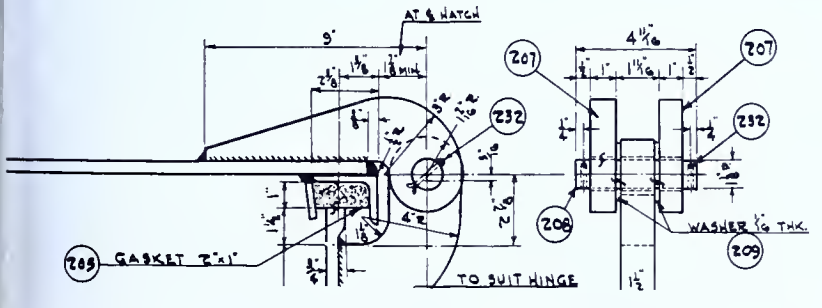


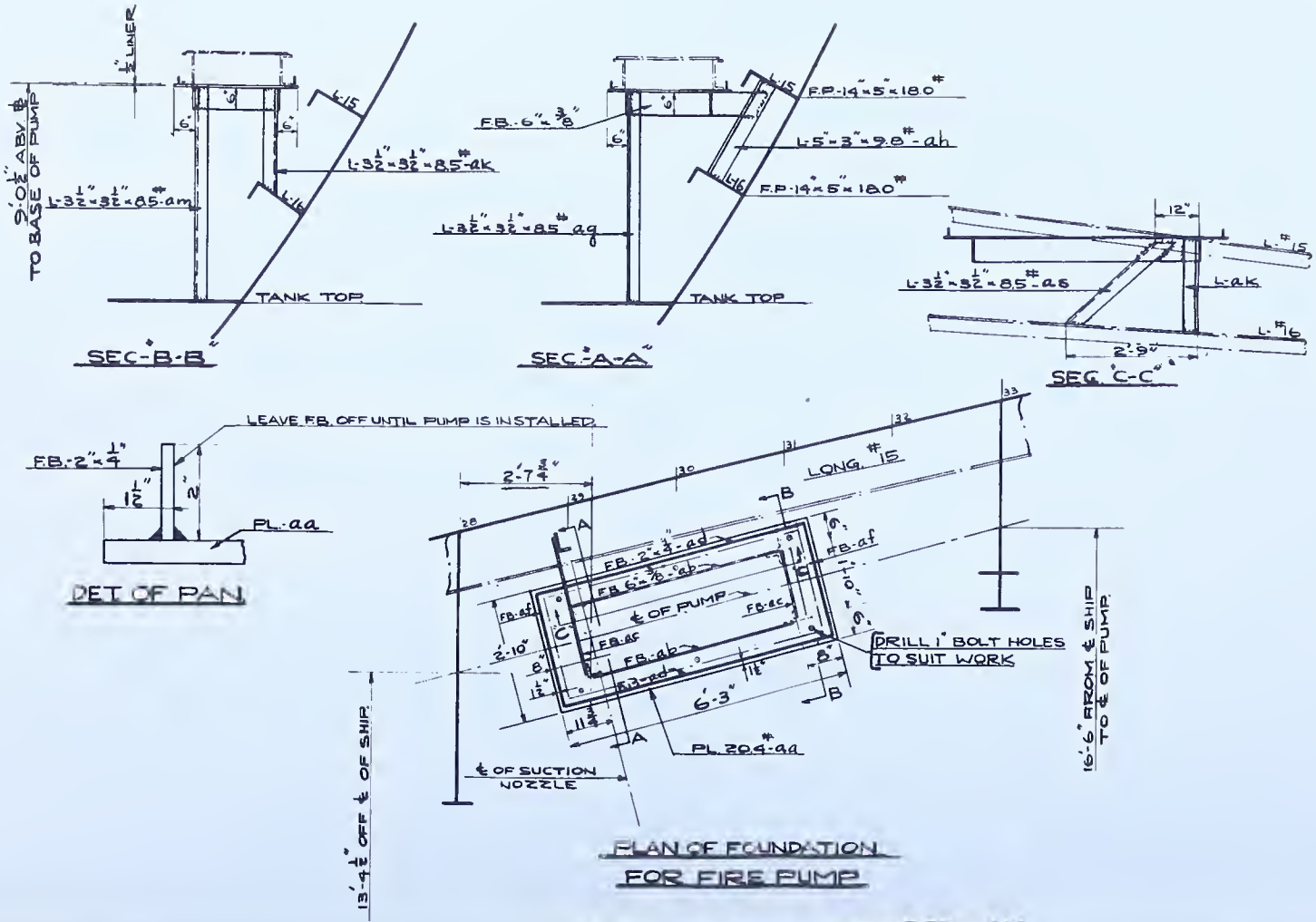
O.T. HATCH FOR FORWARD CARGO TANK.

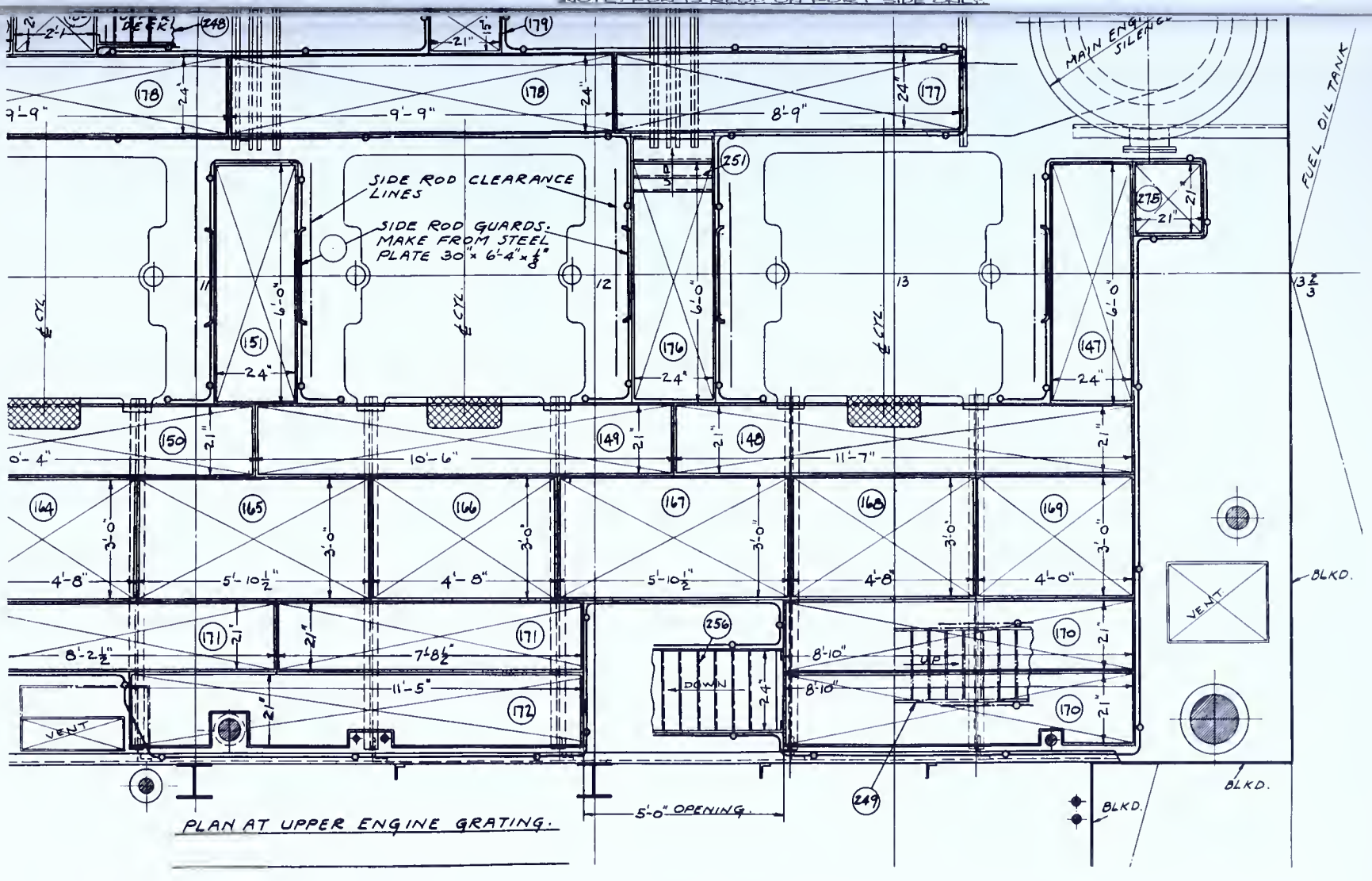


SECTION "C-C"

O.T. CARGO HATCH




½" LINER
2'-0½" ABV ℄ TO BASE OF PUMP
L-15
L-16
L-3½"×3½"×8.5#-ak
L-3½"×3½"×8.5#-am
TANK TOP
SEC-B-B
FB-6"×⅜"
F.P.-14"×5"×18.0#
L-5"×3"×9.8#-ah
L-3½"×3½"×8.5#-aq
SEC-A-A
12"
L-3½"×3½"×8.5#-as
L-ak
2'-9"
SEC. C-C
LEAVE FB. OFF UNTIL PUMP IS INSTALLED.
FB.-2"×¼"
1½"
2"
PL.-aa
DET OF PAN
LONG. #15
2'-7¾"
FB.-2"×⅜"-ad
FB 6"×⅜"-ab
FB.-af
℄ OF PUMP
FB.-ae
FB.-ag
FB.-ac
FB.-ad
2'-10"
1½"
11¾"
6'-3"
PL. 20.4#-aa
DRILL 1" BOLT HOLES TO SUIT WORK
℄ OF SUCTION NOZZLE
13'-4½" OFF ℄ OF SHIP
16'-6" FROM ℄ SHIP TO ℄ OF PUMP
PLAN OF FOUNDATION FOR FIRE PUMP
NOTE: FDN. IS REQD ON PORT SIDE ONLY.



PLAN AT UPPER ENGINE GRATING.

PRINT NO. 12, Page 221

Questions and Problems

PRINT NO. 1

1. Locate the after perpendicular.
2. What is the distance from frame 20 to frame 30?
3. Locate the double bottom.
4. Are the bulkheads surrounding the crew's recreation room a part of the hull?

PRINT NO. 2

5. Give the height of shaft at frame #2 and at frame #6.
6. What is the greatest distance the stern frame extends below the base line?
7. Give the location of the foremost part of the stern frame.
8. What designates whether the stern frame is made up of castings forgings, or fabricated?

PRINT NO. 3

9. What is the thickness in inches of shell plate G-6?
10. Locate the forward end of shell plate C-5.
11. Locate L-21 / 68-71. Which way does it heel?
12. Is frame 70 forward or aft of the frame line?

PRINT NO. 4

13. What does the symbol at A represent?
14. Locate bracket marked "ad", and give size.
15. What is the depth of the center deck girder?
16. Give two sizes of lightening holes shown.

PRINT NO. 5

17. Give scantling of L9.
18. What type of connection does plate marked "am" have to the side shell?
19. Give size of a limber hole as shown on transverse frame #69.
20. Which way are flanges on transverse frame #69 turned?

PRINT NO. 6

21. Give scantlings of deck longitudinals as used between bulkhead #68 and #71.
22. What types of connections in way of seams and butts are indicated?
23. What is the weight of plate B5 UD ?
24. Locate four transverse oil-tight bulkheads.

PRINT NO. 7.

25. What is the thickness in inches of L12?

. Draw a cross section of plate marked (AX), giving all sizes.

. What type of fastening is used on through brackets in way of longitudinal 19?

. Give distance from ℄ to outboard side of longitudinal bulkhead.

PRINT NO. 8

. Draw a cross section of FR. 57 at 24' waterline.

. Give size of weld for T-bar connecting longitudinal bulkhead assembly to panel plate.

. Give over-all size of the largest unit that will be pre-assembled before installation, as shown on this print.

. What side of panel plate does the T-bar lap?

PRINT NO. 9

. What are the over-all dimensions of the cutout in ℄ "acb" for door?

. What size stiffeners are used on bulkhead 11'-9" off ℄, frames 86 to 93?

. What is the length and width of the chain locker?

. Locate in the plan view of upper deck, the transverse bulkhead at frame 97, as shown on this plan.

. How thick are the collars at the top of the longitudinal bulkhead, 11'-0" off ℄?

PRINT NO. 10

. How many dogs are required on oil-tight hatch for forward cargo tank? Give piece numbers.

. What does the mark *f* on piece #207 indicate?

. What is the thickness in inches of the coaming PLT.

PRINT NO. 11

. What is the distance from the bottom of "ac" to the base line?

. Make a sketch illustrating the proper method of leveling this foundation.

. Give piece mark of all sections which would have stock left on for fitting.

. When should the 1" bolt holes in the top plate be drilled?

PRINT NO. 12

5. What are the outside dimensions of the longest piece of grating shown?

6. What is the width of ladder 256? Is the top or bottom of this ladder shown?

7. Is the grating above or below the upper deck level?

8. Are pieces #177 and #176 the same distance above the ℄?

APPENDIX II

Shipbuilding Terms, Definitions, and Abbreviations

TERMS AND DEFINITIONS

A

baft--Aft of; farther aft than.

ccess Holes--Holes cut in ship's structure to permit entering or leaving various compartments.

ccommodation Ladder--A portable set of steps on a ship's side for the accommodation of people boarding from small boats or from a pier.

ft--Toward, at, or near stern.

fter--Nearer stern.

ftermost--Nearest the stern.

fter Body--Hull form aft of the midship section.

fter Peak--The compartment in the narrow part of the stern, aft of the last water-tight bulkhead.

fter Peak Bhd.--Watertight bulkhead farthest aft.

fter Perpendicular--A vertical straight line at, or near, the after edge of rudder post.

ir Hammer--Hammer driven by compressed air for riveting, sometimes called an air gun or "gun".

ir Port--A circular opening or window through the ship's side, or deck house, for light or ventilation.

midships--At or near the midship section of the ship.

nchor--A heavy hook-shaped device for holding a ship at rest in water. The anchor grips the ocean bottom and is fastened to the ship by a chain.

ngle Clip--A short piece of angle bar.

Angle Collar--A ring made of angle bar.

Anneal--To soften metal by heating and allowing it to cool slowly.

Aperture--A recess in which the propeller is located.

Apron Plate--Small plate on top of bulwark, at stem of vessel to stiffen bulwark.

Assemble--To fit together small parts, in making a large section, or part.

Athwartship--Across the ship at right angles to the centerline.

Auxiliaries--Machinery supplementary to main propulsive units.

Awning Deck--Shade deck above another deck.

B

Ballast--Any weight or weights (usually sea water) used to keep the ship from becoming "top heavy" or to change her trim.

Ballast Tank--Watertight compartment to hold ballast.

Barnacle--Small marine growth which attaches itself to a vessel's hull in large numbers, often greatly retarding her speed.

Battens--Long strips of wood used in the mold loft for fairing lines; also, wooden protective strips in cargo holds; see hatch battens.

Beam--An athwartship member supporting a portion of a deck. Also, the width of the ship.

Beam Knee--(See Bracket)

Below--Below a deck or decks (corresponding to "down stairs").

Bending Rolls--Large machine used to give curvature to plates.

Bending Slab--Heavy cast iron perforated slabs arranged to form a large floor on which frames, etc., are bent.

Berth--A place for a ship; a place to sleep; a bunk; also, a specified small section of the hull structure.

Between Decks--The space between any two decks.

Bevel--The angle between the flanges of a frame or other member. (When greater than a right angle, open bevel; when less, closed). Also, to chamfer.

Bilge--Curved section between the bottom and the side of a ship; the recess into which all water drains.

Bilge Blocks--Supporting blocks used under bilge for support during construction or dry-docking.

Bilge Keel--A fore and aft member fitted to the outside of the shell plating along the bilge, to prevent excessive rolling of the ship.

Bilge Pump--Pump for removing bilge water.

Bilge Strake--Course of plates at the bilge.

Bilge Water--Water in ship due to leaks, sweat, etc.

Bilge Well--A sump to which bilge water drains.

Binnacle--A case, box, or stand containing a ship's compass, adjusting magnets, and a lamp for use at night.

Bitt--A vertical post used in making fast lines; a bollard.

Bitumastic--An elastic cement used in place of paint to protect steel.

Boat Deck--A deck on which lifeboats are kept.

Body Plan--A drawing which shows frame lines in elevation.

Boiler--Container in which water is heated to form steam.

Boiler Chocks--Stay braces which prevent fore and aft movement of boilers.

Boiler Foundation--A support for a boiler.

Bollard--A single tie post (see bitt).

Booby Hatch--A watertight covering over a deck opening, which is used for a stairway or ladder.

Boom--A long, round, heavy spar, pivoted at one end, usually used for handling cargo, etc.

Boom Rest--A support for a boom when the boom is not in use.

Boom Step--A socket for end of boom.

Bosom Piece--A short piece of angle riveted over a butt joint of two angles, a butt strap for angle bars; a splice piece.

Boss--The curved swelling portion of the ship's hull around the propeller shaft.

Boss Frame--A hull frame which is bent for clearing propeller shaft tube.

Boss Plate--A shell plate covering the curved portion of hull where the propeller shaft passes outboard.

Bow--The forward end of a ship.

Bracket--A triangular plate used to connect rigidly two or more parts, such as a deck

beam to a frame, a frame to a margin plate, etc.

Braze--To heat and join by means of hard solder (spelter). This may be brass, bronze, or other alloys.

Breakwater--A braced guard plate which prevents solid water from sweeping the decks.

Breast Hook--A triangular-shaped plate extending horizontally across the bow behind the stem, stiffening the stringers and stem.

Bridge, Navigating--A deck from which the ship is navigated.

Bridge Deck--A deck of the superstructure amidships.

Brow--A watershed over an airport; a small inclined runway to allow passage of trucks over hatch coaming, or through bulkhead door, etc.; sometimes portable.

Building Slip--A place where the ship is built; a shipway.

Bulb Angle--An angle shape, which is reinforced at one toe.

Bulb Plate--A narrow plate reinforced on one edge.

Bulb Tee--A Tee bar with toe of web reinforced.

Bulkhead--A vertical partition corresponding to the wall of a room, extending either athwartships or fore and aft. A steel partition in a ship.

Bulkhead Sluice--A small opening in a watertight bulkhead which can be opened or closed from the deck above.

Bulwark--The ship's side above the weather deck.

Bull Riveting--Driving rivets by squeezing them with a high powered air or hydraulic machine.

Bunker--A compartment used for the stowage of coal or other fuel.

Buoyancy--Ability to float; lifting power when immersed.

Butt--The joint formed when two parts are placed edge to edge.

Buttock--A distance from centerline; an intersection of moulded surface with a vertical longitudinal plane.

Butt Strap--A small plate used to connect the two parts of a butt joint by overlapping each; a splice piece.

C

Camber--The athwartship rise or crown of a deck.

Cant Frame--A frame which is not square to the keel line.

Capstan--A revolving drum, with vertical axis, used for heaving in lines.

Cargo--The freight carried by a ship.

Cargo Battens--Strips of wood used to keep cargo away from the steel hull.

Cargo Boom--A heavy boom used in handling cargo.

Cargo Hatch--A large opening in a deck which permits the loading of cargo into holds.

Cargo Port--An opening in a ship's side used in loading and unloading cargo.

Casing--Bulkheads enclosing portion of vessel, as the boiler room casing. Also a covering for parts of machinery.

Caulk--To make a joint watertight.

Caulker--One who caulks.

Ceiling--Wood sheathing on the tank top, sides of ship, and bulkheads; used to protect cargo.

Center Keelson--(See vertical keel).

Center Line--The middle line of the ship, extending from stem to stern.

Chafing Plate--A bent plate used in minimizing chafing of ropes, as at hatches.

Chain Locker--A compartment in the forward portion of ship in which anchor chain is stowed.

Chain Pipe--A pipe for passage of anchor chain from deck to chain locker.

Chain Riveting--Two or more rows of rivets spaces so that the rivets in one row are opposite those in an adjacent row.

Chain Stopper--A device which prevents anchor chain from running out. It is moved into position after the anchor has been dropped.

Chamfer--To cut off the sharp edge of a 90° corner. To trim to an acute angle.

Chart Room--A small room adjacent to the Pilot House in which charts and navigating instruments are located.

Chock--A heavy fitting through which ropes or hawsers may be led. A saddle or seat of wood or metal.

Chock-Boat--A cradle or support for a lifeboat.

Chock-Roller--A chock with a sheave to prevent chafing of ropes.

Cleat--A fitting having two arms or horns around which ropes may be made fast. A clip on the frames of a ship used to hold cargo battens in place.

Clinching Pan --A flat plate for clinching nails. (Used in the mold loft.)

Coaming--The vertical boundary of a hatch or skylight.

Cofferdam--A narrow vacant space between two bulkheads. A double watertight bulkhead.

Collar--A flanged band or ring. A welded plate used to close a frame or beam penetration through plating.

Collision Bulkhead--The watertight bulkhead nearest the bow of a ship; forepeak bulkhead.

Companionway--A covered stairway leading downward from an open deck. A series of steps leading from the deck to a cabin or saloon below; also, the space occupied by these steps.

Compartment--A subdivision of space or room in a ship.

Corrugated--Having a series of wrinkles or grooves arranged so as to produce stiffness.

Corrugated Bulkheads--Bulkheads with corrugated plating, eliminating the need for many welded stiffeners.

Counter--Overhang of the stern of a ship.

Countersink--To taper a hole for a flush rivet or bolt.

Cowl--The hood-shaped top of a ventilator pipe.

Cradle--A form on which bows, etc., are assembled. The support in which a ship rests during launching; a launching cradle.

D

Davit--A crane arm used in handling small boats, lifeboats, stores, gear, etc.

Dead Flat--A portion of a ship's side or bottom where the plating has no curvature; also, the midship portion of constant cross section. (The parallel middle body.)

Dead Rise--The rise or upward slant of the bottom of a

ship from the keel to the bilge.

Deadweight--The total weight of cargo, fuel, water, stores, passengers and crew, and their effects, which a ship can carry.

Deck--A part of a ship corresponding to the floor of a building.

Deck-house--A shelter built on deck.

Declivity--Inclination of shipways to provide for launching.

Deep Tank--A deep compartment usually extending from tank top to lower deck.

Derrick--A device for hoisting heavy weights, cargo, etc.

Die--A tool for forming a rivet head (applied to rivet dies).

Displacement--The total weight of the ship when afloat, including everything on board, (equals weight of water displaced.) Usually expressed in long tons.

Dog--A small bent metal fitting used in closing doors, hatch covers, manhole covers, etc.; a bent bar of round iron used in holding shapes on bending slab; any small flat lug temporarily welded to structure as backing for a wedge.

Dolly Bar--A heavy bar to hold against a rivet, to give backing when riveting.

Double Bottom--Compartments at bottom of ship between inner and outer bottoms, used for ballast tanks, water, fuel oil, etc.

Doubling Plate--A plate fitted outside or inside of another to give extra strength or stiffness.

Drag--The amount the stern end of the keel is below the bow end when the ship is afloat, but not on an even keel.

Draft--The vertical distance of the lowest point of the ship below the surface of the water, when afloat.

Drift Pin--A small tapered tool used in aligning holes in adjacent members.

Drop Strake--A strake discontinued near the bow or stern.

E

Erecting--The process of hoisting into place and bolting the various parts of a ship's hull.

Even Keel--A ship is said to be on an even keel when the keel is level or parallel to the surface of the water.

Expansion Trunk--Raised portion of tank used on some oil tankers to allow for the expansion of oil when temperature changes.

Eye Bolt--Bolt whose head is in the form of a ring or eye.

F

Fabricate--To make raw material ready for assembling or erection.

Face Plate--A narrow stiffening plate welded along the edge of any web frame or stiffener.

Fairing or Fairing Up--Correcting or fairing up a ship's lines or structural members; assembling the parts of ship so that they will be fair, that is, without kinks, bumps, or waves; bringing the rivet holes into alignment.

Fairlead--A fitting through or over which a rope, line, etc., may be led so as to change its direction without excessive friction.

Fairwater--Plate or casting used to preserve streamline flow past hull structure or propeller hub.

Fathom--Six feet.

Fathometer--A device to measure the depth of water, by timing the travel of a sound wave from the ship to the ocean bottom and return.

Faying Surface--The contact surface between two adioining parts.

Fender--A portable device to protect a ship when bumping a pier; sometimes made of wood, rope, etc.; permanently installed extension which protects the hull of a ship in docking.

Fidley--Casing top over boiler room.

Fidley Hatch--A hatch over boiler room.

Flagstaff--Flagpole at stern of ship; ensign staff.

Flange--A part of a plate or shape at, or nearly at, right angles to main part; to bend over to form an angle.

Flare--The sudden widening of the shell at top near the bow.

Flat--A small partial deck (built level) without curvature.

Floor--The lower portion of a transverse frame, usually a vertical plate extending from center line to bilge, and from inner to outer bottom.

Fore and Aft--In line with the length of the ship, longitudinally.

Fore and Aft Gangway--A walkway between deckhouses at or near centerline of ship.

Forebody--A hull form forward of the midship section.

Forecastle--The forward upper portion of the hull, sometimes used for the crew's quarters.

Forefoot--The part of the keel which curves and rises to meet the stem.

Forepeak--The large compartment or tank, at the bow in the lower part of the ship.

Forepeak Bulkhead--Collision bulkhead; bulkhead nearest bow.

Forging--Steel worked to special shape by hammering while red hot.

Forward--Near, at, or toward, the bow of the ship.

Forward Perpendicular--A vertical line through the intersection of the stem with the load water line.

Foundations--Supports for boilers, engines, and auxiliary machinery.

Foundations, Auxiliary--Supports for small machinery, such as winches, condensers, heaters, etc.

Frames--Ribs forming the skeleton of a ship.

Frames-Continuous--Frames combining side frames and floors.

Frame, Side--Frame inside a ship, above and connecting to margin plate or floor plates.

Frame Spacing--The fore and aft distance between adjacent frames.

Frame, Web--A heavy side or continuous frame, made with web plate for extra stiffness.

Freeboard--The vertical distance from the upper watertight deck to waterline, when the ship is fully loaded.

Freeboard Mark-- (See Plimsoll mark).

Freeing Port--Hole through bulwark which provides ready drainage of water from deck.

Funnel--A smokestack of a vessel.

Furnace--A heater or large forge for heating plates or shapes for bending; to bend by heating in furnace.

G

Galley--A cook room or kitchen.

Galley Dresser--A cook's work table.

Galvanizing--Coating metal parts with zinc for protection from rust.

Gangway--A passageway, a ladder, or other means of boarding a ship.

Garboard Strake--The course of plates next to the keel of a ship.

Gasket--Packing of canvas composition, or other material, used in making a tight joint.

Girder--Fore and aft stiffening member for deck or bottom shell.

Girth--Any expanded length.

Grab Rods--Bent rods welded to bulkheads or ship's side to form a ladder.

Grating--Light platform or walkway built up of metal bars, used for access to machinery.

Grommet--A soft ring used under a nut or bolthead to maintain water tightness.

Gross Tonnage--A figure obtained by dividing the total volume of the ship, in cubic feet, by 100.

Ground Ways--Timbers secured to the ground, under the hull on each side of the keel, on which a ship is launched.

Gudgeons--Bosses on stern post drilled for pins (pintles) on which rudder swings.

Gunwale--The junction of deck and shell at top of sheer strake.

Gunwale Bar--Angle iron which connects stringer plate and shell plates. (Riveted work)

Gyro-Compass--A mechanical compass operated by means of a gyroscope. This compass indicates true north rather than magnetic north.

Gyro-Repeater--An apparatus to show the reading of the gyro compass at a distance from the main gyroscope equipment.

H

Hatch--An opening in a deck for passage of cargo, etc.

Hatch Battens--Flat bars which are wedged against hatch coamings to secure tarpaulins.

Hatch Beam--A portable beam used to support wooden hatch covers.

Hawse Pipe--Casting, or castings, through deck and side of ship at bow for passage of anchor chain.

Hawser--A large rope used in towing or mooring.

Heeling--The inclination of a vessel to one side.

Hogging--Straining of the ship which tends to make the bow and stern lower than the middle portion.

Hold--The inside of a hull; cargo space.

Hold Beams--Structural members placed in a hold, similar to deck beams, but having no plating or planking on them.

Holder-On--One who "backs up" or "holds on" the head of a rivet while the point is being "driven", or upset.

Horn--To line or square-up; also, part of a cleat.

Hull--The body of a ship, including shell plating, framing, decks, bulkheads.

I

I-Beam--A structural shape with cross section resembling the letter I.

Inboard--Inside of the ship; toward or nearer the center line.

Inboard Profile--A drawing of the longitudinal section at center line of ship.

Inner Bottom--Plating forming the upper surface of the double bottom. Also called tank top.

Inner Shell--A plated surface or "shell" inside the outer shell plating, used as additional protection in case of collision or other accidents. The space between the inner and outer shells is often used as a storage space for liquid ballast or cargo.

Inserted Packing--Red lead-soaked canvas strips placed between connections that cannot be caulked successfully; stop waters.

Intercostal--Made in separate parts; between frames, beams, etc.; the opposite of continuous. (Floors are continuous; longitudinal girders are intercostal in most cargo vessels.)

Isherwood System--A system of building ships in which the main framing is longitudinal or fore and aft, instead of transverse as in ordinary ships.

J

Jack Staff--A flagstaff at the bow of a ship.

Joggle--An abrupt bend or offset in a plate, bar, or frame to eliminate the use of liners.

K

Keel--The principal fore and aft member of a ship's frame. The keel runs along the bottom, connecting the stem and stern, and to it are attached the frames of the ship.

Keel-blocks--Heavy blocks which support the keel of the ship during construction.

Keel, Flat--The bottom shell strake on centerline of ship.

Keelson, Side--Fore and aft member placed on either side of, and similar to, the vertical keel.

Keel, Vertical--Vertical plate used as reinforcement for keel, often called center-keelson.

King Post--A stub mast, outboard from center line, used to carry cargo booms; kingposts often serve as ventilators.

Knot--A tie in a line. A nautical mile. (About one and one-seventh statute miles.)

Knuckle--A sharp bend in a plate or shape.

Knuckle Plate--A plate bent to form a knuckle.

L

Ladder--Inclined steps, used aboard ship in place of "stairs".

Lap--A joint in which one part overlaps the other, thus avoiding the use of a butt strap; also, the amount of overlap.

Launching--The operation of placing a hull in the water by allowing it to slide down on greased skids, called launching ways.

Laying Out--Marking plates or shapes, for shearing, punching, etc.

Lazarette--Ship's storeroom between decks.

Length Between Perpendiculars--The length of a ship measured from the forward perpendicular to the after perpendicular.

Length Over All--The length of a ship measured from the

extreme forward end to the aftermost point of the stern.

Lift--To make a template from measurements taken from the job.

Lightening Hole--A hole cut in any member to reduce its weight.

Limber Hole--A small hole cut in a plate near the bottom to permit the passage of water.

Liner--A flat or tapered strip of steel placed under a plate or shape to bring the member in line with another which it overlaps. A filler.

Lines--The form of a ship as represented by its moulded surface.

List--To lean over to one side.

Load Waterline -Line of surface of water on a ship when loaded to designed draft.

Loftsman--A workman in the mold loft, who lays down ship lines and makes templates.

Longitudinal--A shell, deck, or bulkhead stiffener running fore and aft.

Lug pad-A projection on deck with hole for fastening a block for a lead.

M

Magnetic Compass--A device which indicates the direction of magnetic north by means of a magnetized needle (or needles) which is attracted towards the Earth's magnetic pole. Magnetic north is not to be confused with true or geographical north.

Main Deck--Usually the deck immediately below the shelter or weather deck.

Manhole--A hole cut in a bulkhead, tank top, etc., to allow the passage of a man.

Margin Plate--The outboard row of plates of the inner bottom, connecting to the shell plating at the bilge.

Marker--A brass pipe dipped into paint which is used in marking rivet holes.

Marlinspike--A pointed tapering tool which is used in separating strands of rope or cable in splicing.

Mast--A large long spar, placed nearly vertical on the center line of a ship.

Mess Room--A dining room for officers or crew.

Midship--At or near the middle point of a ship's length.

Midship Section--A cross section through the ship, midway between the forward and after perpendiculars.

Mold Loft--A shed or building with large, smooth floor on which the lines of a ship can be drawn to full scale.

Mooring--Securing a ship in position by several lines or cables, so that she cannot move or swing; anchoring.

Mooring Pipe--A casting which prevents chafing of mooring lines passing through bulwark plating.

Mould or Mold--A light pattern of a part of a ship; usually made of thin wood or paper. Also called a template.

N

Net Tonnage--A figure obtained by making deduction from the gross tonnage for space not available for carrying cargo.

O

Oakum--Untwisted fibres of old rope treated with a composition of resin and pitch, used to fill seams of wooder decks.

Offset--To move out of line or position.

Offsets--A table of moulded dimensions for waterlines, decks, etc.

Oil Tight--Sealed by welding or caulking to prevent oil leakage. (Closer rivet spacing is required than for watertight work.)

Old Man--A rig for holding a drilling machine.

On Board--On or in the ship.

On Deck--On the upper deck; in the open air.

Outboard--Away from the center-line, towards the side of a ship.

Overboard--Outside; over the side of a ship; into the water.

Overhang--That portion of the hull which is over and unsupported by the water.

Oxter Plate--Bent shell plate which fits around upper part of stern post; also called tuck plate.

P

Packing--Material which is placed between plates or shapes to make them watertight; wooden blocks and wedges which support a ship on sliding ways; spacers.

Pad Eye--An eye located on deck which is used for fastening cables; on the hull, an attachment for hanging a block and fall for lifting propeller or rudder.

Palm--Flattened top portion of rudder stock (for bolted connection). Also, a flat surface at the end of a strut or stanchion.

Panting--An in-and-out movement of plating; to pulsate or throb. Panting may be caused by the lift and fall of a ship in a seaway, or by engine vibration.

Peak--A narrow compartment at either end of a vessel.

Pelorus--An instrument used for taking directional bearings or sights, similar to a compass but without magnetic needles.

Pillar--A vertical member or column which provides support to a deck girder. (Also termed a stanchion.)

Pilot House--An enclosed place in which the main steering wheel, controls, engine room telegraph, etc., are located. A wheel house.

Pintle--A pin on which a rudder hinges.

Pitch--Spacing; as of rivets or gear teeth.

Planking--Wood covering for decks, etc.

Plating--The plates of a hull, a deck, a bulkhead, etc.

Plimsoll Mark--A mark placed on the ship's side to indicate maximum allowable draft.

Pontoon Hatch Cover--A steel box-shaped member sometimes used in place of hatch beams to close in a cargo hatch.

Poop--The after, upper portion of the hull, often containing the steering gear.

Poop Deck--The first deck above the shelter deck at after end of a vessel.

Port--A harbor; An opening in the side of a ship. The left hand side of a ship (looking toward the bow.)

Porthole--A circular opening in the ship's side (see air-port).

Profile--A side elevation of a ship's form.

Propeller--A rotating device which drives a ship through the water.

Propeller Post--The forward post of stern frame, which is bored for propeller shaft

Propeller Shaft--Rotating bar by means of which the engine turns the propeller.

Q

Quarters--Living or sleeping rooms.

R

Rabbet--A depression or offset designed to take some other adjoining part; as for example, the rabbet in the stem to take the shell plating.

Rail--The upper rounded edge of the bulwarks.

Rake--Slope aft of a mast, kingpost or stack.

Reaming--Enlarging a rivet hole by means of a revolving, cylindrical, slightly tapered tool with cutting edges running along its sides.

Reverse Frame--An angle bar or other shape riveted to the inner edge of a transverse frame as reinforcement.

Ribband--A fore and aft wooden strip or heavy batten which is used to temporarily align the transverse frames after erection.

Rigging--Ropes, wire ropes, lashings, masts, booms, etc.; also, the handling and placing on board the ship of heavy weights and machinery.

Rivet--A short round metal connection used to fasten two or more members together by clinching after being heated red hot.

Roll--To impart curvature to a plate. Also, the motion of the ship from side to side, alternately raising and lowering each side of the deck.

Roller Chock--(See Chock Roller.)

Rose Box--A screen or strainer placed around the end of a bilge suction pipe.

Rudder--A flat piece or structure of wood or metal attached upright to the sternpost (or in single screw-vessels, to the rudder post) of a vessel by hinges, or pintles and gudgeons, so that it can be turned, as by a tiller, causing the vessel's head to turn in the same direction, because of the resistance offered to the water by the rudder.

Rudder Post--After post of stern frame to which the rudder is hung. (Also called stern post.)

Rudder Stock--The shank of a rudder which extends through shell upward to the steering engine.

Rudder Stop--Lug to limit the swing of the rudder.

S

Sagging--Straining of the ship which tends to make the middle portion lower than the bow and stern.

Samson Post--A heavy vertical post which supports cargo booms; kingpost.

Scantlings--The dimensions of various shapes.

Scarf--To thin out or taper a corner or edge of a plate or shape to make a lap. A joint in a stem, bar keel or stern frame.

Screen Bulkhead--A bulkhead, usually placed between the engine room and boiler room, which is fire proof, dust proof, and gas tight.

Scupper--A deck drain.

Scupper Pipe--A pipe which drains water from scuppers through the side of a ship.

Scuttle--A very small hatch; a manhole.

Scuttle Butt--A container for drinking water.

Sea Chest--A compartment through which sea water is admitted or discharged.

Seam--A riveted or welded plate edge connection. A riveted seam overlaps; a welded seam may or may not overlap.

Set--Metal mold or template for use on bending slab.

Set Iron--A bar of soft iron used on bending slab to give shape of frames.

Shaft Alley--A casing (large enough in which to walk), covering the propeller shaft and extending from engine room to after peak.

Shaft Tunnel--(See Shaft Alley.)

Shape--A bar of constant cross section, such as a channel, T-bar, angle bar, etc. Also, to impart curvature to a plate or other member.

Shear Line--A line at which a shearing cut is to be made.

Shears--A large machine for cutting plates and shapes.

Sheer--Curvature of deck in a fore and aft direction as seen in profile. (See Part I-"Lines of a Ship".)

Sheer Plan--A side elevation of ship's form; a profile.

Sheer Strake--The top full course of side shell plating.

Shell Expansion--A plan showing details of all shell plating and shell longitudinals. (Longitudinals would appear only on tankers.)

Shell Landings--Points on the frames where the edges of shell plates are to be located.

Shell Plating--The plates forming the outer skin of the hull.

Shelter Deck--A continuous superstructure deck above the freeboard deck.

Shore--A temporary brace or prop.

Sight Edges--Visible edges of plating (outside shell and above decks).

Skylight--An opening in a deck to give air and light to the compartment below it.

Sliding Way--That part of launching way which moves with the ship.

Slop Chute--Chute for dumping garbage overboard.

Sounding Pipe--Vertical pipe in oil or water tank used in measuring depth of liquid in tank.

Spar--Long, round member such as mast or boom; part of rigging.

Stability--The tendency of a ship to remain upright.

Staging--Planks or scaffolding on which to stand when working on sides or under decks.

Stanchion--A pillar or upright post.

Stapling--Collars, forged from angle bars, which fit around continuous members passing through bulkheads or decks, to insure water tightness.

Starboard--The right hand side of a ship, looking forward.

Stay--A guy line.

Stealer--A plate extending into an adjoining strake as at the end of a drop strake.

Steering Gear--Apparatus for controlling the rudder.

Stem--Forging, casting, or plating forming extreme bow of ship and extending from keel to forecastle deck.

Step--To set in place (as applied to a mast); also, a socket for the end of a mast; a

support for the fixed or "hinged" end of a boom.

Stern--The after or back end of a vessel.

Stern Frame--A large casting or forging attached to the after end of hull to form the ship's stern. It includes rudder post, propeller post, and aperture for the propeller.

Stern Tube--A long bushing or bearing through the stern to support the end of a propeller shaft.

Stiffener--An angle bar, T-bar, channel, etc., used to stiffen plating of a bulkhead or other member.

Stool--A support for a propeller shaft bearing in the shaft alley. A foundation, etc.

Stop Water--Canvas and red lead, or other material, fitted between two metal parts to make a watertight joint.

Stowage--A support or fastening for any gear, as, anchor or boat stowage.

Strake--A fore and aft course, or row, of shell or other plating.

Stringer--A fore and aft member used to give longitudinal strength. Depending on location, these are called hold stringers, bilge stringers, side stringers, etc.

Stringer, Deck--The strake of deck plating which contacts the shell.

Stringer Plate--A deck plate at the outboard edge of deck connected to the shell of a ship with an angle or a welded joint.

Strong Back--A supporting girder for a hatch cover; a rig used in straightening bent plates; a bar for locking cargo ports.

Strut--a support for a propeller tail shaft (used on ships with more than one propeller).

Super-structure--Deck houses, etc., which are located above shelter deck.

Swash Plate--A baffle plate in a tank which prevents excessive surging of a liquid.

T

Tail Shaft--A short section of a propeller shaft extending through the stern tube and carrying the propeller.

Tank Top--The plating over the double bottom.

Tarpaulin--A waterproof canvas covering for a hatch or other purpose.

Tee-bar--A structural shape with cross section resembling the letter T.

Telegraph--A mechanically- or electrically-operated means of signalling from bridge to engine room, etc.

Template--A mold or pattern.

Thrust Bearing--A bearing or block to resist end thrust. A bearing on propeller line shaft which relieves the engine from the driving force of the propeller.

Thwart--A seat in a lifeboat.

Tiller--An arm, attached to rudder head, which operates the rudder.

Transom--The main frame at the rudder stock (cant frames usually radiate from the transom frame).

Transverse--Athwartships; at right angles to the keel.

Transverse Frames--Athwartship members forming the ship's "ribs".

Trim--To shift ballast; to cause a ship to change its position in the water; drag.

Trunk--A small casing passing through a deck, such as is used for ladders or ventilation.

Tumble Home--An inboard slant of a ship's side above the bilge.

U

Uptake--Connection between boilers and smokestack.

V

Vertical Keel--A row of vertical plates extending along the center of the flat plate keel. It sometimes is called the center keelson.

Voice Tube--A large speaking tube.

W

Water Line--Any one of certain lines of a ship parallel with (and at various heights above) the base line. In half-breadth plans the waterlines are smooth curves showing the shape of the ship; in profile plans they are projected as straight lines.

Watertight--So riveted, caulked, or welded as to prevent the passage of water.

Waterway--A narrow passage along the edge of a deck for drainage. A gutter.

Ways--Timbers, etc., on which a ship is built or launched. (See Launching.)

Weather Deck--A deck exposed to the weather.

Web--The vertical portion of a beam, the thwartship portion of a frame, etc.

Web Frame--A frame with a deep web.

Welding--Fusing together two or more members with electric arc or by other means.

Well--A cofferdam or a sump in the double bottom.

Wheel--Nickname for propeller; steering gear control.

Winch--A small hoisting engine; used in pulling lines, or in handling cargo.

Windlass--A machine used to hoist the anchors by winding in the anchor chain.

Wind Scoop--A device used to divert air into a compartment of a ship.

Z

Zee-bar--A structural shape with a cross section resembling the letter Z.

Zig-zag Riveting--Two or more rows of rivets spaced so that the rivets of one row are offset.

ARC WELDING TERMS

(As defined in *Procedure Handbook of Arc Welding Design and Practice*--Lincoln Electric Company, and in *Definitions of Welding Terms and Master Chart of Welding Processes*--American Welding Society. Reprinted by permission.)

Arc Welding--A non-pressure (fusion) welding process wherein the welding heat is obtained from an electric arc formed either between the base metal and an electrode, or between two electrodes.

Automatic Welding--Welding with equipment which automatically controls the entire welding operation. (Including feed, speed, oscillation, interruption, etc.)

Axis of a Weld--A line through the weld parallel to the root.

Back-Step Welding--A welding technique wherein the increments of weld metals are deposited opposite to the direction of progression.

Backing Strip--Material (metal, asbestos, carbon, etc.) backing up the root of the weld.

Bare Electrode--(Lightly coated). A solid metal electrode with no coating other than that incidental to the manufacture of the electrode, or with a light coating.

Base Metal--(Parent Metal) The metal to be welded or cut.

Bead Weld--A type of weld made by one passage of electrode or rod.

Continuous Weld--A weld which extends uninterruptedly for its entire length.

Crater--A depression at the termination of an arc weld.

Deposited Metal--Metal that has been added by a welding process.

Depth of Fusion--The depth of fusion of a groove weld is the distance from the original surface of the base metal to that point within the joint at which fusion ceases.

Effective Length of Weld--The length of the correctly proportioned cross section of a weld.

Electrode Holder--A device used for mechanically holding the electrode.

Flush Weld--A weld made with a minimum reinforcement.

Flux--A fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides or other undesirable inclusions formed in welding.

Forge Welding (Blacksmith, Roll Hammer)--A group of pressure welding processes wherein the parts to be welded are brought to suitable temperature by means of external heating and the weld is consummated by pressure or blows.

Fusion Welding--A group of welding processes in which metals brought to the molten state at the surfaces to be joined are welded with or without the addition of filler metal and without the application of mechanical pressure or blows.

Gas Cutting--The process of severing ferrous metals by means of the chemical action of oxygen on elements in the base metal.

Gas Pocket (Blow-Hole)--A cavity in a weld caused by gas inclusion.

Gas Welding--A non-pressure (fusion) welding process wherein the welding heat is obtained from a gas flame.

Hand (Face Shield)--A protective device used in arc welding for shielding the face and neck, equipped with suitable filter glass lens and designed to be held by hand.

Heat-Affected Zone--The portion of base metal whose structure or properties has been altered by the heat of welding.

Helmet Shield--A protective device used in arc welding for shielding the face and neck, equipped with suitable filter glass lens and designed to be worn on the head.

Manual Weld--A weld made by an operator unaided by mechanically or electrically controlled equipment.

Metal Arc Cutting--The process of severing metals by melting with the heat of the metal arc.

Peening--Mechanical working of metal by means of hammer blows.

Preheating--Heat applied to base metal prior to welding or cutting.

Residual Stress--Stresses remaining in a structure or member as a result of thermal or mechanical treatment, or both.

Shielded Metal Arc Welding--A metal arc welding process wherein the arc and weld metal is protected from the atmosphere by a shielding medium.

Spot Welding--A resistance welding process wherein the fusion is confined to a relatively small portion of the area of the lapped parts to be joined.

Tack Weld--A weld used for assembly purposes only.

Unaffected Zone--That portion of the base metal outside of the heat-affected zone wherein no change in physical properities and/or structure has taken place.

Weaving--A technique of depositing weld metal in which the electrode is oscillated at right angles to the direction of travel.

Weld--A localized consolidation of metals by a welding process.

Welded Joint--A localized union of two parts by welding.

Welding Rod--Filler metal, inwire or rod form, used in the gas welding process and those arc welding processes wherein the electrode does not furnish the metal.

ABBREVATIONS USED BY SHIPFITTERS

E--After end (rear or stern)
LT--Alteration
MM--Ammunition
.P.--After peak
.P.--After perpendicular
UX--Auxiliary
.A.--Bulb angle
ET--Between
EV--Bevel
HD--Bulkhead
RKT--Bracket
--Base line
.M.--Bolted manhole cover plate
/M--Bill of material
OT--Bottom
TK--Buttock
--Channel or channels
L or ℄--Center line
OFF--Cofferdam
SK--Countersink holes
SK-OS--Countersink other side
OMP'T--Compartment
OND--Condenser
ONN--Connection
.to C.--Center to center
.R.C.--Closed roller chock
.T.C.--Closed towing chock
TRS--Centers
.V.K.--Center vertical keel
D or DIA--Diameter
DBLR--Doubler
DIM--Dimension
K or DK--Deck
DN or DWN--Down
DR--Door
ELEV--Elevation
E.M.--Expanded metal
E.R.--Engine room
EXH--Exhaust
EXP--Expanded
f--Finish
F.B.--Flat bar
F.D. BLOWER--Forced draft blower
FDK--Forecastle deck
FE--Forward end (front or bow)
F.K.--Flat keel
FLG--Flange
F.O.--Fuel oil
FOCS'LE--Forecastle
FORD orFWD--Forward
FND--Foundation
F.P.--Forepeak or forward perpendicular
F.P.--Flanged plate
FR--Frame
F.W.--Fresh water
GALV--Galvanize
GEN--Generator
GIR--Girder
H-Hull or "H"-Beam
HLS--Holes
H.P.--High pressure or horse power
H.R.--Half round
I--"I"-beam
IB--Inboard
I.D.--Inside diameter
INV--Inverted
KP--Kingpost
L--Angle, locker, length, or longitudinal
L.B.P.--Length between perpendiculars
LBS or #--Pounds
L.O.A.--Length over all
L or LONG--Longitudinal
L.P.--Low pressure
LUB OIL--Lubricating oil
L.W.L.--Load waterline
MAX--Maximum
MIN--Minimum
M.L.--Moulded line
MLD--Moulded
M.P.--Mooring pipe
N--Near
NO-CSK--No countersink
NO or #--Number
N.W.T.--Non-water tight
OB--Outboard
O.C.--Open chock
O.D.--Outside diameter
OPP--Opposite side
O.S.--Other side
O.T.--Oil tight

O.T.H.--Oil tight hatch
P--Port
P.C.--Pitch circle
PDK--Poop deck
PLT or ℄--Plate
PLTG--Plating
PM--Pitch mark, check mark, or spot
R or RAD--Radius
R.C.--Roller chock
REQ--Required
RIV--Rivet
R.O.T.M.H.--Raised oil tight manhole
R.P.M.--Revolutions per minute
S or STBD--Starboard
SC.DR.--Screen door
SDK--Shelter deck
$--Shear or seam
S.N.W.T.--Steel non-watertight
S.P.--Shell plate
S.R.--State room
STIFF--Stiffener
STR--Stringer
S.W.T.--Steel water-tight
T--"T"-bar
T.C.--Towing chock
TEMP--Template
THD--Thread
THK--Thick
TRANS--Transverse
T. S.--This side
T.S.U.--This side up
T.T.--Tank top
U--Up
UDK--Upper deck
V--Vent
V.K.--Vertical keel
V.L.--Vertical ladder
W--Weld
W.C.--Water closet
WL--Waterline
W.R.--Wardrobe or washroom
W.T.--Water-tight
W.T.M.H.--Watertight manhol
Z--"Z" bar

--Midship section

APPENDIX III

Reference Tables for Shipfitters

Table XV -- Tools Often Used by Shipfitters

?ERSONAL PROPERTY)	(SUPPLIED BY COMPANY)
ɔcket knife	Soapstone
wo foot rule	Pencils
ix foot rule	Chalk
ifty foot steel tape	Center punch
and hammer (ball peen)	Wood punch
ix inch square	Tit punch
wo foot square	"C" clamps (4" and 6")
evel (20" or 24")	Spring clips
lumb bob	Maul
halk line	Drift pins
evel	Jacks
wl	Wrenches
ividers	Declivity board

Table XVI -- Decimal Equivalents

	1/64	.015625		33/64	.515625
	1/32	.03125		17/32	.53125
	3/64	.046875		35/64	.546875
1/16		.0625	9/16		.5625
	5/64	.078125		37/64	.578125
	3/32	.09375		19/32	.59375
	7/64	.109375		39/64	.609375
1/8		.125	5/8		.625
	9/64	.140625		41/64	.640625
	5/32	.15625		21/32	.65625
	11/64	.171875		43/64	.671875
3/16		.1875	11/16		.6875
	13/64	.203125		45/64	.703125
	7/32	.21875		23/32	.71875
	15/64	.234575		47/64	.734375
1/4		.25	3/4		.75
	17/64	.265625		49/64	.765625
	9/32	.28125		25/32	.78125
	19/64	.296875		51/64	.796875
5/16		.3125	13/16		.8125
	21/64	.328125		53/64	.828125
	11/32	.34375		27/32	.84375
	23/64	.359375		55/64	.859375
3/8		.375	7/8		.875
	25/64	.390625		57/64	.890625
	13/32	.40625		29/32	.90625
	27/64	.421875		59/64	.921875
7/16		.4375	15/16		.9375
	29/64	.453125		61/64	.953125
	15/32	.46875		31/32	.96875
	31/64	.484375		63/64	.984375
1/2		.50	1		1.

Table XVII — Table of Measurements for Laying Out Angles

0^{o} - 90^{o}

gle "A"	Base	Altitude	Angle "B"	Angle "A"	Base	Altitude	Angle "B"	Angle "A"	Base	Altitude	Angle "B"
1^{o}	100	1-3/4	89^{o}	16^{o}	100	28-5/8	74^{o}	31^{o}	100	60-1/8	59^{o}
2^{o}	100	3-1/2	88^{o}	17^{o}	100	30-5/8	73^{o}	32^{o}	100	62-1/2	58^{o}
3^{o}	100	5-1/4	87^{o}	18^{o}	100	32-1/2	72^{o}	33^{o}	100	65	57^{o}
4^{o}	100	7	86^{o}	19^{o}	100	34-3/8	71^{o}	34^{o}	100	67-1/2	56^{o}
5^{o}	100	8-3/4	85^{o}	20^{o}	100	36-3/8	70^{o}	35^{o}	100	70	55^{o}
6^{o}	100	10-1/2	84^{o}	21^{o}	100	38-3/8	69^{o}	36^{o}	100	72-5/8	54^{o}
7^{o}	100	12-1/4	83^{o}	22^{o}	100	40-3/8	68^{o}	37^{o}	100	75-3/8	53^{o}
8^{o}	100	14	82^{o}	23^{o}	100	42-1/2	67^{o}	38^{o}	100	78-1/8	52^{o}
9^{o}	100	15-7/8	81^{o}	24^{o}	100	44-1/2	66^{o}	39^{o}	100	81	51^{o}
10^{o}	100	17-5/8	80^{o}	25^{o}	100	46-5/8	65^{o}	40^{o}	100	83-7/8	50^{o}
11^{o}	100	19-1/2	79^{o}	26^{o}	100	48-3/4	64^{o}	41^{o}	100	86-7/8	49^{o}
12^{o}	100	21-1/4	78^{o}	27^{o}	100	51	63^{o}	42^{o}	100	90	48^{o}
13^{o}	100	23-1/8	77^{o}	28^{o}	100	53-1/8	62^{o}	43^{o}	100	93-1/4	47^{o}
14^{o}	100	24-7/8	76^{o}	29^{o}	100	55-3/8	61^{o}	44^{o}	100	96-5/8	46^{o}
15^{o}	100	26-3/4	75^{o}	30^{o}	100	57-3/4	60^{o}	45^{o}	100	100	45^{o}

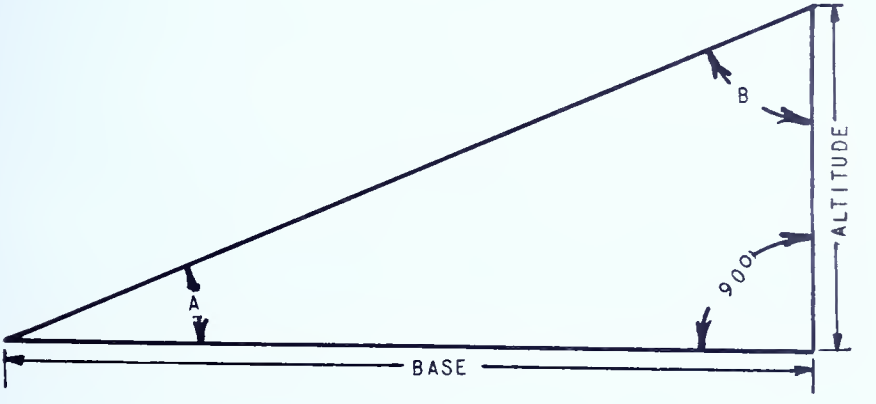


Table XVIII-- Weight per Linear Foot of Angle Bar

(Thickness in Inches)

	1/8"	3/16	1/4"	5/16	3/8"	7/16	1/2"	9/16	5/8"	11/16	3/4"	13/1
1" x 1"	.80	1.16	1.49									
1¼" x 1¼"	1.01	1.48	1.92	2.33								
1½" x 1½"	1.23	1.80	2.34	2.86	3.35							
A2" x 2"	1.65	2.44	3.19	3.92	4.7	5.3						
C-2½ x 2½"	2.08	3.07	4.1	5.0	5.9	6.8	7.7					
E3" x 3"			4.9	6.1	7.2	8.3	9.4	10.4	11.5			
H-3½ x 3½"			5.8	7.2	8.5	9.8	11.1	12.4	13.6	14.8	16.0	17.1
H4" x 4"			6.6	8.2	9.8	11.3	12.8	14.3	15.7	17.1	18.5	19.9
S5" x 5"					12.3	14.3	16.2	18.1	20.0	21.8	23.6	25.4
U6" x 6"					14.9	17.2	19.6	21.9	24.2	26.5	28.7	31.0
8" x 8"							26.4	29.6	32.7	35.8	38.9	42.0
B-2½ x 2"	1.86	2.75	3.62	4.5	5.3	6.1	6.8					
3" x 2"			4.1	5.0	5.9	6.8	7.7					
D3" x 2½"			4.5	5.6	6.6	7.6	8.5	9.5				
F-3½ x 2½"			4.9	6.1	7.2	8.3	9.4	10.4	11.5	12.5		
G-3½ x 3"			5.4	6.6	7.9	9.1	10.2	11.4	12.5	13.6	14.7	15.8
K4" x 3"			5.8	7.2	8.5	9.8	11.1	12.4	13.6	14.8	16.0	17.1
X4" x 3½"				7.7	9.1	10.6	11.9	13.3	14.7	16.0	17.3	18.5
Y4½" x 3"				7.7	9.1	10.6	11.9	13.3	14.7	16.0	17.3	18.5
N5" x 3"				8.2	9.8	11.3	12.8	14.3	15.7	17.1	18.5	19.9
O5" x 3½"				8.7	10.4	12.0	13.6	15.2	16.8	18.3	19.8	21.3
P5" x 4"					11.0	12.8	14.5	16.2	17.8	19.5	21.1	22.7
R6" x 3½"				9.8	11.7	13.5	15.3	17.1	18.9	20.6	22.4	24.0
T6" x 4"					12.3	14.3	16.2	18.1	20.0	21.8	23.6	25.4
W7" x 3½"					13.0	15.0	17.0	19.1	21.0	23.0	24.9	26.8
8" x 3½"						16.5	18.7	21.0	23.2	25.3	27.5	29.6
8" x 6"						20.2	23.0	25.7	28.5	31.2	33.8	36.5
2½ x 1½"		2.44	3.19	3.92								
2" x 1½"	1.44	2.12	2.77	3.39	3.99							

Table XIX -- Standard Gauges for Channels

Channels	Diameter of Rivets						
	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"
6" x 1.92"x1.92" x 8#	1"	1"	15/16"				
6" x 3½" x 3½" x 15#			2"	2"	2"	1-7/8"	1-3/4"
8" x 2-7/8"x2-7/8"x17.6#				1-1/2"	1-7/16"		
10"x 3-3/8"x3-3/8"x21.7#				1-7/8"	1-7/8"	1-3/4"	1-5/8"

Standard Gage for "I" Beams = 1-5/8 x Dia. Rivet From Toe of Flange

Table XX -- Standard Flanges for Plates

Weight of Plate	Size of Rivet	Width of Flange	Gage
2½#	1/4	1-1/16	7/16
5 #	3/8	1-5/8	15/16
7½#	1/2	2-13/16	1-1/4
10 #	5/8	2-3/4	1-5/8
12½#	5/8	2-13/16	1-11/16
15 #	3/4	3-3/8	2"
17½#	3/4	3-7/16	2-3/16
20 #	7/8	4"	2-3/8
22½#	7/8	4-1/16	2-7/16
25 #	7/8	4-1/8	2-1/2
27½#	7/8	4-3/16	2-9/16
30 #	1"	4-3/4	2-7/8
32½#	1"	4-13/16	2-15/16
35 #	1"	4-7/8	3"
37½#	1'	4-15/16	3-1/16

Table XXI — Rivet Diameters

(Diameters Expressed in Inches)

	Diameter of Rivet							
	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"
No. Rivet Diameters								
1-5/8	3/8"	5/8"	13/16	1"	1-1/4"	1-7/16"	1-5/8"	1-13/16"
2-1/2	5/8"	15/16"	1-1/4"	1-9/16"	1-7/8"	2-3/16"	2-1/2"	2-13/16"
3	3/4"	1-1/8"	1-1/2"	1-7/8"	2-1/4"	2-5/8"	3"	3-3/8"
3-1/4	13/16"	1-1/4"	1-5/8"	2"	2-7/16"	2-7/8"	3-1/4"	3-11/16"
3-1/2	7/8"	1-5/16"	1-3/4"	2-13/16"	2-5/8"	3-1/16"	3-1/2"	3-15/16"
4	1"	1-1/2"	2"	2-1/2"	3"	3-1/2"	4"	4-1/2"
4-1/2	1-1/8"	1-11/16"	2-1/4"	2-13/16"	3-3/8"	3-15/16"	4-1/2"	5-1/16"
5	1-1/4"	1-7/8"	2-1/2"	3-1/8"	3-3/4"	4-3/8"	5"	5-5/8"
5-3/4	1-7/16"	2-1/8"	2-7/8"	3-5/8"	4-5/16"	5"	5-3/4"	6-1/2"
6	1-1/2"	2-1/4"	3"	3-3/4"	4-1/2"	5-1/4"	6"	6-3/4"
7	1-3/4"	2-5/8"	3-1/2"	4-3/8"	5-1/4"	6-1/8"	7"	7-7/8"
8	2"	3"	4"	5"	6"	7"	8"	9"
9	2-1/4"	3-3/8"	4-1/2"	5-5/8"	6-3/4"	7-7/8"	9"	10-1/8"
10	2-1/2"	3-3/4"	5"	6-1/4"	7-1/2"	8-3/4"	10"	11-1/4"
12	3"	4-1/2"	6"	7-1/2"	9"	10-1/2"	12"	13-1/2"

Table XXII -- Length of Fillet Weld to Replace Rivets

Length of Fillet Welds (to nearest 1/8")

Rivet or Bolt Dia.	1/2"	5/8"	3/4"	7/8"	1"
Rivet shear value @ 12,000#/Sq. In.	2356	3682	5301	7216	9425
1/4" bead					
"Fusion code"	1-1/2"	2-1/8"	3"	3-7/8"	5"
Shielded arc	1-1/4"	1-3/4"	2-3/8"	3-1/8"	4'
5/16" bead					
"Fusion code"	1-1/4"	1-3/4"	2-3/8"	3-1/8"	4"
Shielded arc	1"	1-3/8"	2"	2-1/2"	3-1/4"
3/8" bead					
"Fusion code"	1"	1-1/2"	2"	2-5/8"	3-3/8"
Shielded arc	7/8"	1-1/4"	1-3/4"	2-1/8"	2-3/4"
1/2" bead					
"Fusion code"	7/8"	1-1/8"	1-1/2"	2"	2-5/8"
Shielded arc	3/4"	1"	1-1/4"	1-3/4"	2-1/8"
5/8" bead					
"Fusion code"	3/4"	1"	1-3/8"	1-3/4"	2-1/8"
Shielded arc	5/8"	7/8"	1-1/8"	1-3/8"	1-3/4"

Table XXIII — Standard Charge Numbers for Hull Drawings (As Used by Sun Shipbuilding and Dry Dock Company)

700 - Hull drawings such as profile and general arrangement.
703 - Includes hull castings for stem, stern port and rudder.
704 - Fresh water tanks, winches, and deck castings.
706 - Shell plating.
708 - Center line girders, vertical keel and bilge keel.
710 - Framing.
711 - Longitudinal girders (innercostals).
712 - Side stringers and breast hooks.
714 - Innerbottom plating.
715 - Deck plating.
717 - Bulkheads (transverse).
718 - Longitudinal bulkheads.
719 - Miscellaneous bulkheads between decks.
720 - Transverse and longitudinal engine casing bulkheads, casing top and fidley top.
724 - Hatches, doors, manholes, scuttles.
725 - Airports.
726 - Skylights and lifting gear.
730 - Shaft alley.
732 - Boiler foundations.
734 - Auxiliary machinery foundations in engine and boiler rooms.
740 - Fore and aft gangway and deck houses.
744 - Masts, booms and rigging.
750 - Arrangement of quarters.
752 - Refrigerator space and joiner work.
755 - Casing insulation.
756 - Sanitary bulkheads.
760 - Wood hatch covers (ceilings).
778 - Natural ventilation.
779 - Mechanical ventilation.
780 - Scuppers.
783 - Bitts and chocks.
785 - Anchor handling.
790 - Boat stowage, (boat davits, etc.).
791 - Crew's berths and metal lockers, galley and pantry equipment.
792 - Rail stanchions.
793 - Metal ladders.
794 - Carpentry shop; lamp and paint rooms; engineer's and bos'uns stores.
842 - Stern tube, shafting details.
844 - Ladders and gratings (engine and boiler rooms).
856 - Fireroom hoists, overhead cranes, etc.
900 - Steam and exhaust piping, (deck piping arrangement, etc.).
901 - Sea chests for ballast and sanitary pumps, etc.
905 - Sea chests for water circulating pumps, etc.
915 - Ventilating system, engine and boiler rooms.
918 - Sanitary fixtures.
920 - CO_2 fire extinguishing system.

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